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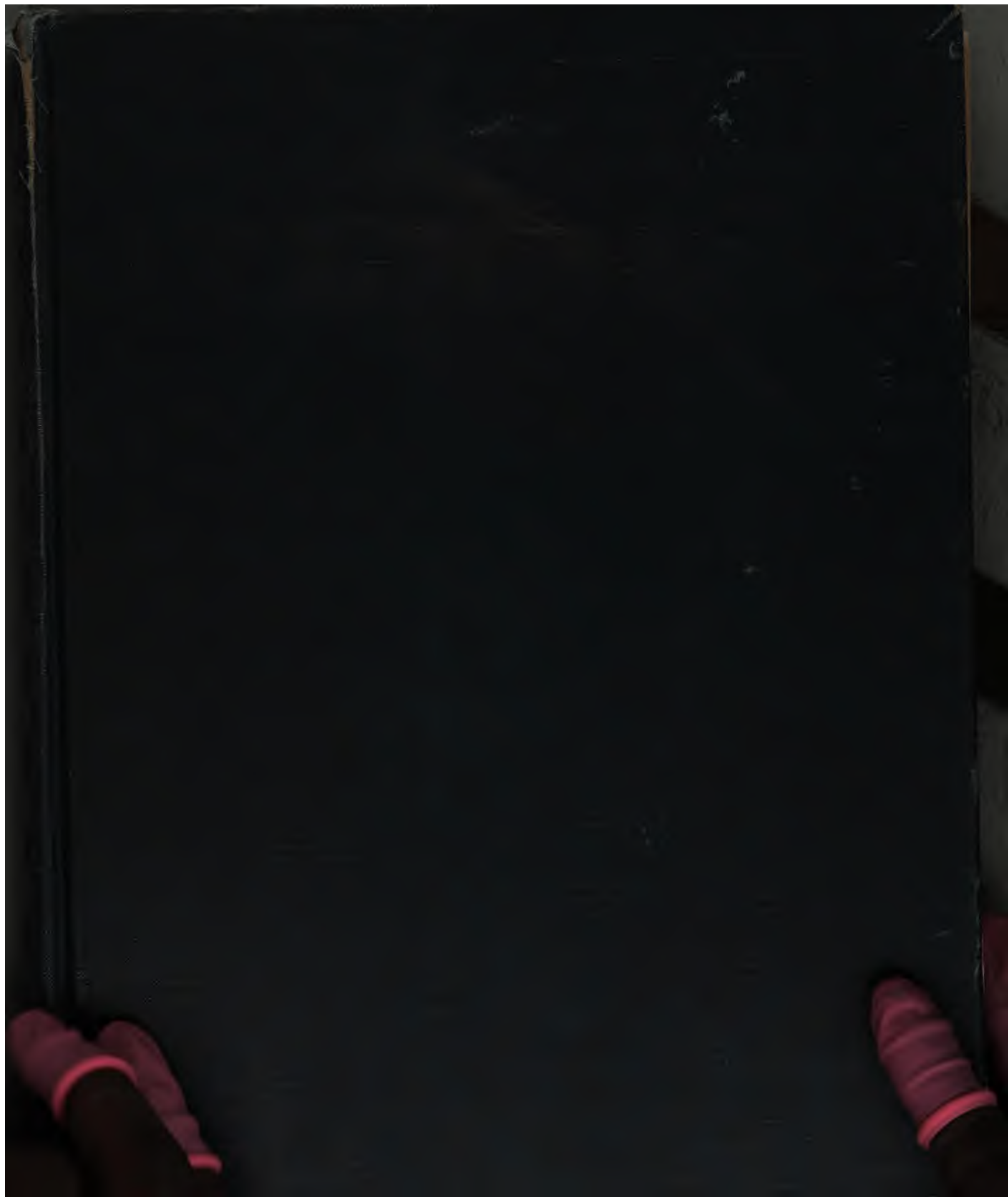
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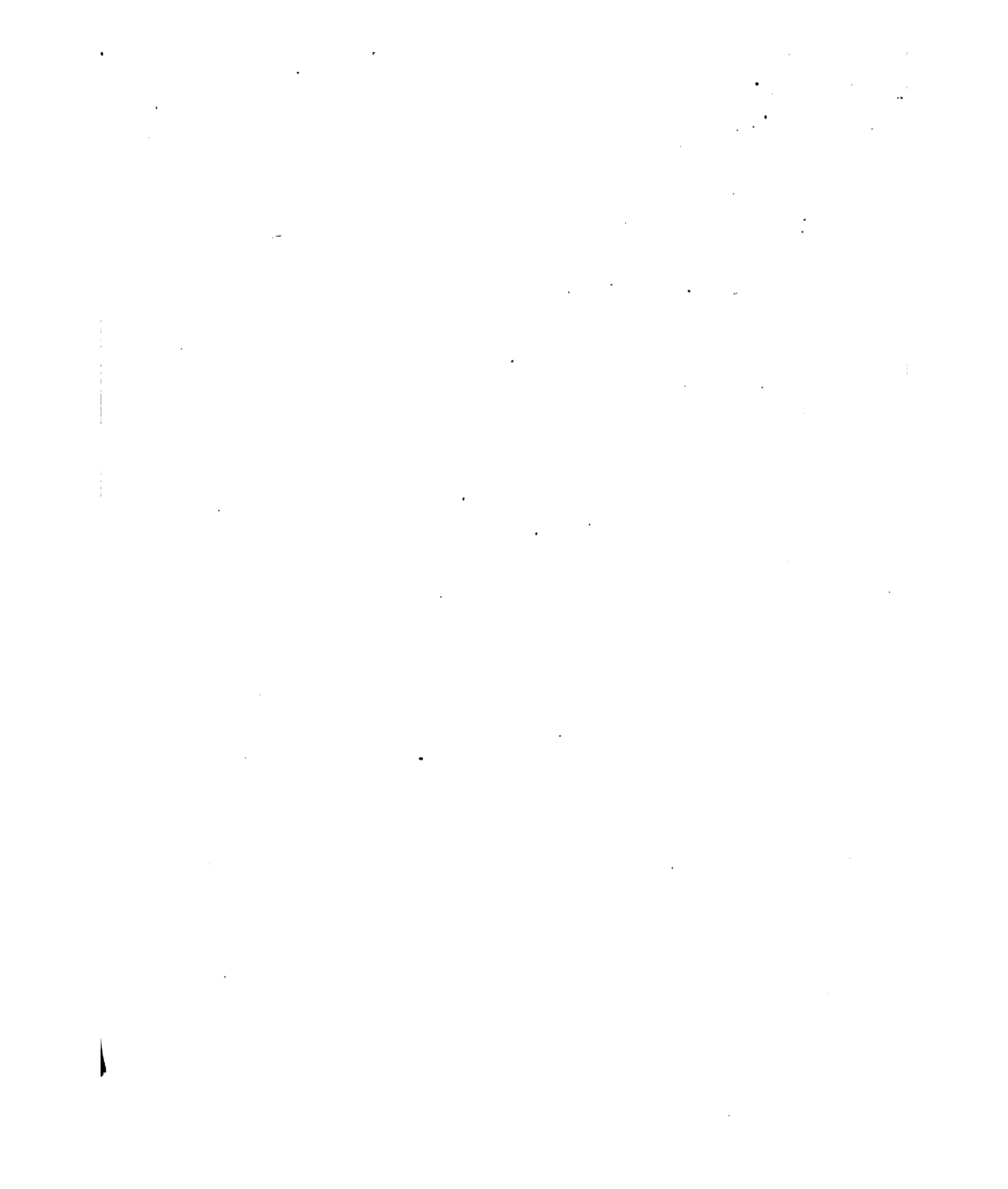


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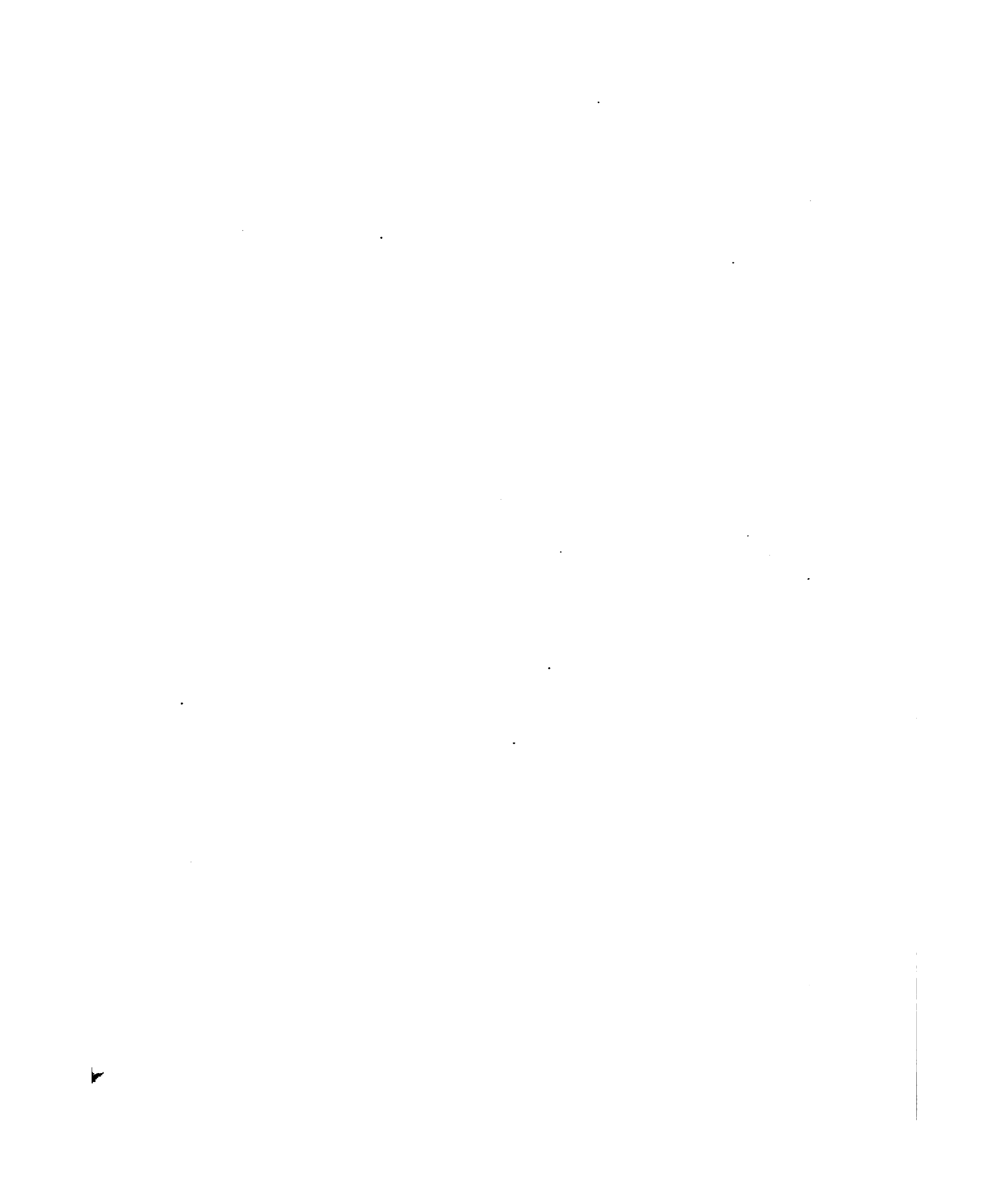
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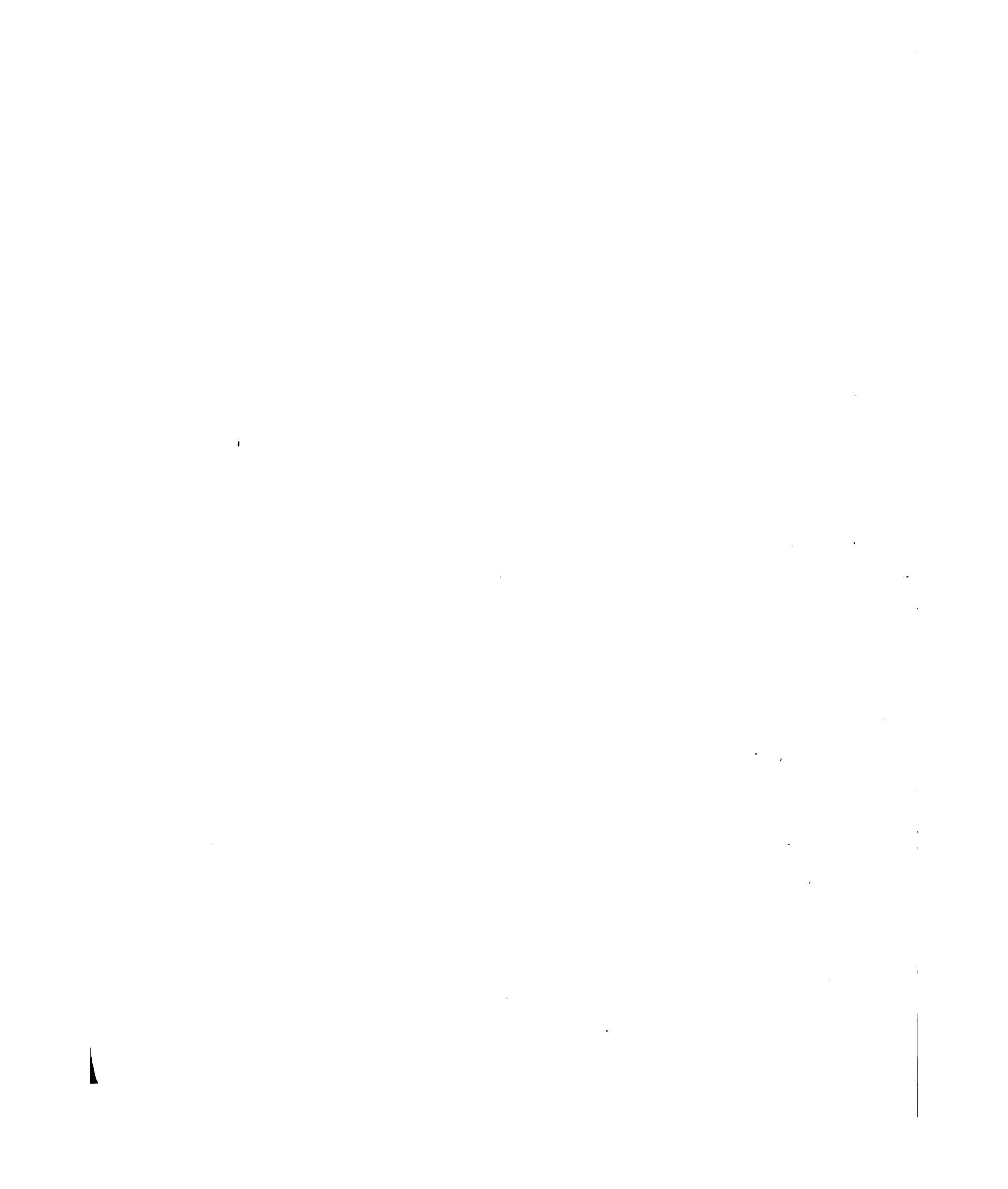
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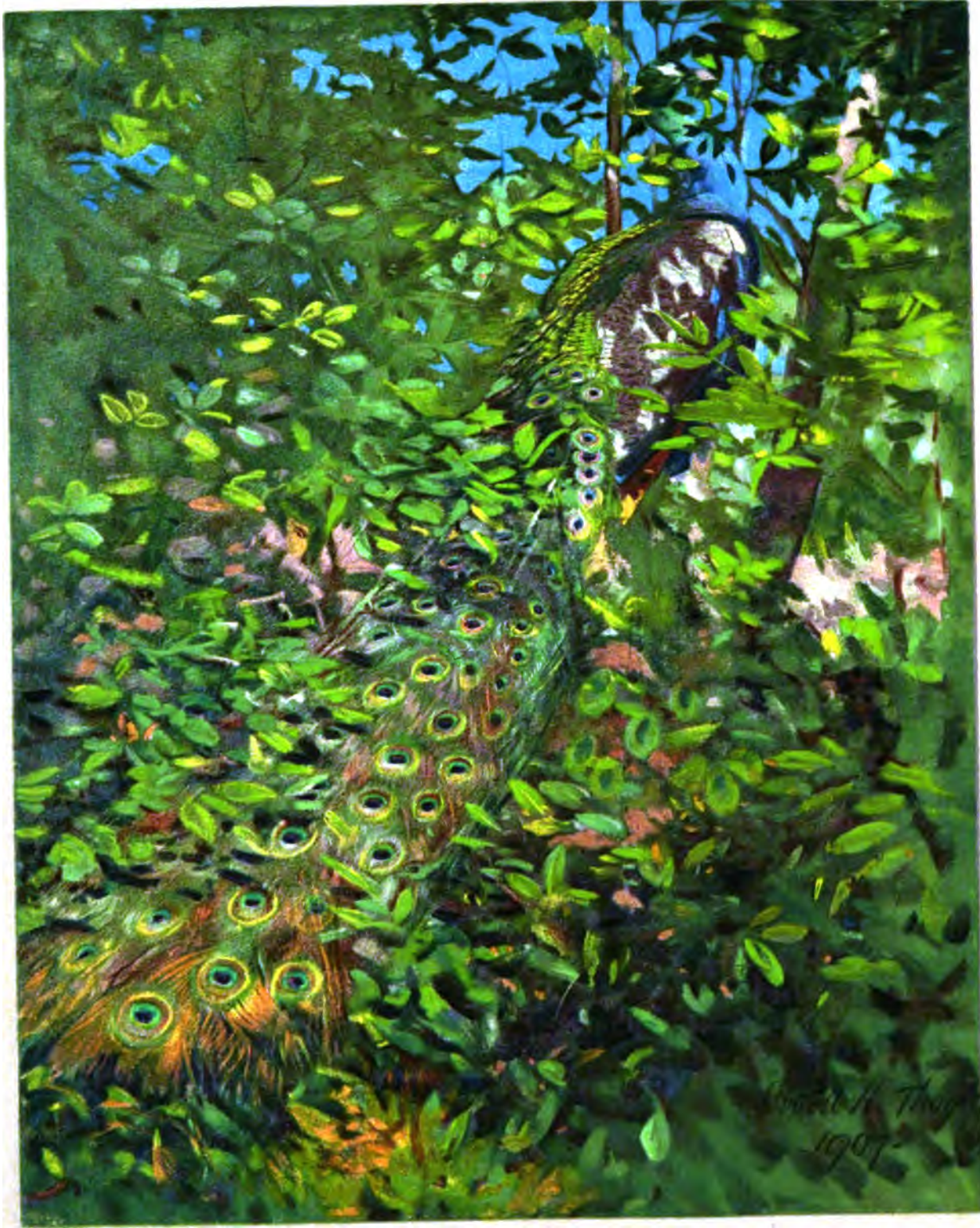


CONCEALING-COLORATION
IN THE
ANIMAL KINGDOM



CONCEALING-COLORATION
IN THE
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PEACOCK IN THE WOODS.

Painted by Abbott H. Thayer, assisted by Richard S. Meryman

The Peacock's splendor is the effect of a marvellous combination of 'obliterative' designs, in forest-colors and patterns. From the golden-green of the forest's sunlight, through all its tints of violet-glossed leaves in shadow, and its coppery glimpses of sunlit bark or earth, all imaginable forest-tones are to be found in this bird's costume; and they 'melt' him into the scene to a degree past all human analysis.

Up in the trees, seen from below, his neck is at its bluest, and when sunlit, perfectly represents blue sky seen through the leaves. Looked *down* on, in the bottom shades of the jungle, it has rich green sheens which 'melt' it into the surrounding foliage. His back, in all lights, represents golden-green foliage, and his wings picture tree-bark, rock, etc., in sunlight and in shadow. His green-blue head is equipped with a crest which greatly helps it against revealing its contour when it moves. Accompanying its every motion, this crest is, as it were, a bit of background moving with it. The bare, white cheek-patch, on the other hand, 'cuts a hole,' like a lighted foliage-vista, in the bird's face. The tail, when spread—or even when shut—'mingles' in a thousand ways with its jungle surroundings. The ocelli, guaranteed by their forest-scenery colors to vanish into the *background* at a short distance, have one peculiarly fantastic use. Smallest and dimmest near the body, and growing bigger and *brighter* in even progression toward the circumference of the tail, they inevitably lead the eye away from the bird, till it finds itself straying amid the foliage beyond the tail's evanescent border.

The *spread* tail looks also very much like a shrub bearing some kind of fruit or flower. Its coppery ground-color (in a front view) represents perfectly that of the bare ground and tree-trunks seen between the leaves. The very positiveness of the design in such details as an ocellus, works to conceal the wearer, on the principle explained in the Introduction by the quotation from Stevenson. The forest is so full of highly individualized vegetable forms, and of many-colored spots and streaks made by their confused outlines, that the predator's eye, watching mainly for *motion*, doubtless gives but slight attention to any of them, or to anything that looks like one of them. In addition to all this, every changed point of view on the beholder's part makes all the bird's details assume new colors and new correlations to each other and to the scene.—A. H. T.

CONCEALING-COLORATION
IN THE
ANIMAL KINGDOM

An Exposition of the Laws of Disguise

Through Color and Pattern:

Being a Summary of

ABBOTT H. THAYER'S
DISCOVERIES

By

GERALD H. THAYER

WITH AN INTRODUCTORY ESSAY BY
A. H. THAYER

ILLUSTRATED BY

ABBOTT H. THAYER GERALD H. THAYER
RICHARD S. MERYMAN AND OTHERS
AND WITH PHOTOGRAPHS

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PREFACE

THE first publication of Abbott H. Thayer's discovery of "The law which underlies Protective Coloration" was in the American journal of ornithology, *The Auk*, in April, 1896. This was followed in the next issue of the same magazine by a supplementary article, "Further remarks on the law which underlies Protective Coloration." The two essays were illustrated by diagrams, and photographs, chiefly of dead birds. They were republished together by the Smithsonian Institution in its "Yearbook" for 1898. A condensed revision of their text, with an introduction by Prof. Edward B. Poulton, was published in the English magazine, *Nature*, in 1902. Mr. Thayer has also given practical demonstrations of his discovery before various congresses of naturalists, both in the United States and in Europe, and has placed models illustrating it in several European museums (Oxford, Cambridge, and South Kensington, England, and Florence, Italy). Thus this newly discovered basal principle of Protective Coloration has been brought to the attention of most of the world's best naturalists, and the bare rudiments of the matter have become to some extent current knowledge among them,—though comparatively few of them have yet given proof that they perceive how completely this and certain parallel subsequent disclosures have revolutionized the study of Protective Coloration, and supplanted former theories. In the last few years, however, this discovery has been rapidly gaining recognition, and mention has been made of it in many writings on Natural History, both popular and scientific, especially in England. Yet the subject is still very far from receiving its destined full and universal appreciation by nature students in general, and much of the current writing about the colors of animals is worse than useless, inasmuch as it works for the retention of antiquated delusions. Indeed, although the study of Protective Coloration

is now generally acknowledged to be one of the most important branches of zoölogical science, there still exists among the otherwise well informed a complete ignorance and misconception of the main laws on which Protective Coloration is based.

The present book has been constructed for two main purposes: First, to lay before the comparatively few naturalists and others who have duly appreciated the original articles on the subject, the results of my father's further researches, with examples of the working of the newly revealed laws in many branches of the animal kingdom; and second, to present the matter, both in its simplest terms and variously elaborated, to a wider circle of readers. We hope thus to clear the way to a more general understanding and more intelligent study of the relations between animals' costumes and their environments. As the book stands, although it has a far wider scope than the previously published articles, it must be considered merely a fragmentary introduction to the huge and fascinating subject of Protective Coloration. Fundamental principles are defined, and many examples are given, both by illustrations and in the text, of the workings of these principles on actual animals; but nothing like an exhaustive examination of the *species* of any branch of zoölogy has been attempted.

For the most part, we do not draw hypothetical conclusions from facts; but we *reveal* certain beautiful facts hitherto unknown; we disclose and explain the remarkable power of several naturally applied laws of optical illusion—as these applications stand, by whatever causes produced, and as all may see them. That is, we show and analyze the *concealing-power* of the colors of animals as they exist to-day.

The illustrations are of particular importance, inasmuch as they include what we believe to be the first scientific paintings ever published of animals lighted as they actually are in Nature. This will be explained in detail later on. The colored pictures have been painted either from mounted specimens, as in the cases of the Grouse, the Wood Duck, and the Peacocks, or from live captives, as in the cases of the Snake and all the Caterpillars. The pic-

ture of the Grouse is a faithful copy of a specimen in a house-lighting artificially arranged to correspond to that which the live bird in the forest would normally have; while the background was painted from photographs and outdoor color sketches. The Snake is the joint production of A. H. Thayer, Rockwell Kent, and G. H. Thayer. Three of the caterpillar pictures are contributed by Louis A. Fuertes. The Bird of Paradise sketch is largely the work of Mrs. A. H. Thayer; likewise most of the background in the rabbit picture, the diagrams of 'ruptive' coloration, and two or three black-and-white diagrammatic drawings; besides a good deal of contributive work here and there on other paintings; and an immense amount of miscellaneous labor, invaluable advice and criticism, at almost every point.

The various photographs of live birds and mammals which appear in the book have been gleaned from periodicals, or secured by special advertising. We are particularly indebted for valuable pictures to the late Mr. Evan Lewis, of Idaho Springs, Colo.; to Mr. Edward R. Warren, of Colorado Springs; to Prof. F. A. Herrick, to Dr. T. S. Roberts, to Mr. George C. Embury, to Prof. F. A. Lucas, and to Mr. C. Wm. Beebe; also to Mr. R. L. Ditmars, Curator of Reptiles at the Bronx Zoölogical Park, New York, for the loan of a live Copperhead snake, and other favors.

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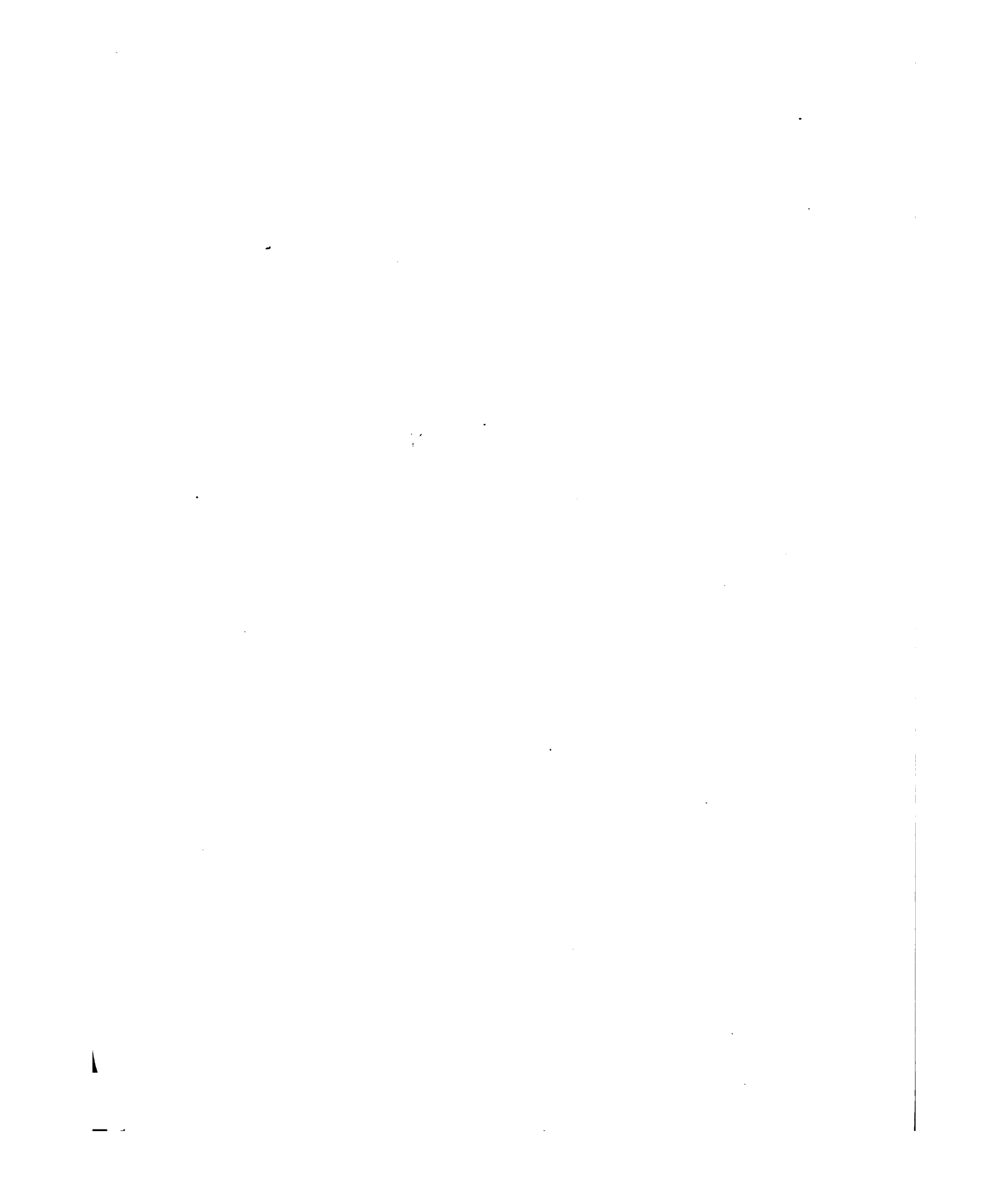
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CONCEALING-COLORATION

IN THE

ANIMAL KINGDOM



INTRODUCTION

WHILE man has gone on wresting from Nature one deep-buried secret after another, the whole field of protective coloration has lain unconcealed, inviting recognition, resplendent with wonderful and beautiful phenomena. Yet of these he has remained uncognizant, or caught only fragmentary glimpses, piecing together the fragments with the aid of false hypotheses, which have presented such a spectacle of inconsistency as to bring the whole subject into widespread contempt.

The entire matter has been in the hands of the wrong custodians. Appertaining solely to animals, it has naturally been considered part of the zoölogists' province. But it properly belongs to the realm of *pictorial art*, and can be interpreted only by painters. For it deals wholly in optical illusion, and this is the very gist of a painter's life. He is born with a sense of it; and, from his cradle to his grave, his eyes, wherever they turn, are unceasingly at work on it,—and his pictures live by it. What wonder, then, if it was for him alone to discover that the very art he practices is *at full*—beyond the most delicate precision of human powers—on almost all animals? Fortunately, although this search, like all others, requires a specialist, the beautiful *things discovered* are appreciable by all men; and our book presents, not theories, but revelations, as palpable and indisputable as radium or X-rays.

Naturalists have not understood the principles of objects' distinguishability. Let us first consider the part distinguishability plays in animals' lives. *Sight*, in the great majority of cases, is the sense by which at the last moment the quarry's fate is decided. Had the cougar, wolf, or fox no eyes, he would starve. Had the hare no sight, he could not tell when to abandon his squatting and spring away, or which way to dodge the murderous leap that would follow. *Scent* brings the predator along the trail or up-wind *nearly* to the game, but were this pursuer blind, he would seldom (except in

holes) * catch anything more active than a tortoise, as everyone knows who has watched a cat, dog, or ferret falteringly nosing out the whereabouts of a bit of flesh, or a setter pointing a bird. The dog commonly points the stream of scent that is passing his nose, without the slightest appearance of knowing where the bird is. In fact, for the purpose of knowing *just* where their game is, scent offers animals no immediate aid; and the same is true of *sound*. For scent and sound can go round corners, whereas sight operates *solely* in a straight line. Sight is also out of all proportion the swiftest; for while scent moves practically only at the air's rate, and sound only 1,121 feet a second, light, which means sight, travels 182,000 *miles* a second! This combined straightness and swiftness gives sight, and sight alone, the power to tell the predator *exactly* where his quarry *now* is, and the quarry where his enemy is. Thus, at these crucial moments in the lives of animals, when they are on the verge of catching or being caught, sight is commonly the indispensable sense. *It is for these moments that their coloration is best adapted, and, when looked at from the point of view of enemy or prey, as the case may be, proves to be 'obliterative.'* All experiment corroborates our supposition that human and animal eyes bear essentially similar relations to light vibrations. (And, in fact, almost all theories about the functions of animal's colors are based on this hypothesis.)

All naturalists perceive the wonderful perfection of the twig mimicry by an inchworm, or of bark by a moth, or of a dead leaf by the *Kallima* butterfly. It is now apparent that almost equally marvelous concealment-devices, in one shape or another, are general throughout the animal kingdom; *the most gorgeous costumes being, in their own way, climaxes of obliterative coloration scarcely surpassed even by moths or inchworms.*

This discovery that patterns and utmost contrasts of color (not to speak of *appendages*) on animals make *wholly* for their 'obliteration,' is a fatal blow to the various theories that these patterns exist *mainly* as nuptial dress, warning colors, mimicry devices (i. e., mimicry of one species by another), etc., since these are all attempts to explain an entirely false conception that

* In the case of the weasel family, this exception is doubtless a large one.

such patterns make their wearer *conspicuous*. So immeasurably great, in the case of most animals, must be the value of inconspicuousness, that such devices as achieve this to the utmost imaginable degree, upon almost every living creature, demand no further reason for being (although doubtless serving countless other minor purposes).

The theory of Natural Selection is based on the belief that organisms are susceptible of modification limited only by the duration of the circumstances causing it, or by the attainment of ultimate perfect fitness to environment. Now, since the same circumstances would always be best met by the same characters in an organism, we are not surprised to find all animals, of however widely different orders, resembling each other in shape and color in evident proportion to their degree of having the same habitat and habits. The whole class of *mammals*, dwelling mainly on the ground, have mainly ground color, and a form varying no more than their situations and habits. The same thing is equally true of thousands of species of birds, of fishes, reptiles and insects; even mammals, if they lead a fish's life, like the cetaceans, have the general shape and color of fishes. (A parallel case is that of humming-birds and hawk moths.) No fish of the open ocean is permitted by Nature to wear any essential color-distinction from his hundreds of neighbor species. He has, for all we know, the same need of "warning colors," "banner marks," etc., as any land animal; but Nature vouchsafes him no pin-point of color beyond that of the sky-lit deep-sea water. The same is true of the inhabitants of the *aërial* ocean spaces. Save for a good many small, bright-colored decorations, mainly of the beaks, worn by such species as breed where such colors abound, Nature allows them no colors which are not those of sea surfaces, clouds and sky, or of somber cliffs; or, for the diving ones, dim water-colors, more like those of the fishes themselves. In short, the so-called "nuptial colors," etc., are confined to situations where the same colors are to be found in the wearer's background, either at certain periods of his life, or all the time. Apparently, not one "mimicry" mark, nor one "warning color" or "banner mark," nor one of Gadow's light-and-shadow-begotten marks, nor any "sex-

ually selected" color, exists anywhere in the world where there is not every reason to believe it the very best conceivable device for the *concealment* of its wearer, either throughout the main part of this wearer's life, or under certain peculiarly important circumstances.*

These deceptive patterns, painted by Nature on the exteriors of almost all animals, will prove to be an inexhaustible field for studying their psychology. Stevenson makes Alan Breck say "Them that cannae tell the truth, should be aye mindful to leave an honest, handy lee behind them. If folk dinnae ken what ye're doing, Davie, they're terrible taken up with it; but if they think they ken, they care nae mair for it than what I do for pease porridge." The psychological principle in this lies deep in Nature's artifices for concealing animals. Wherever, for instance, the animals are habitually to feed amidst brilliant vegetation, she is apt to give brilliant marks rather than simply equipping them to match the soberer interstices amidst the brilliant details. The principle is, evidently, that amidst a large number of similar striking objects, an *imitation of these has the support of the credit of all the real ones*. There are before the eye so many obviously real ones, that the mind refuses to take the trouble to suspect *any*. For a red mark on a bird, fish, or butterfly to pass itself off for a red flower among many red flowers is like Alan's telling the passer-by that his errand is such a familiar one as the search for a runaway horse; while, in such a situation, to try to escape notice by imitating a dusky place, may be as much more risky as for Alan to assert merely that he is not on a mysterious errand.† The so-called "nuptial" costumes of animals are

* Plainly, most details of an animal's body serve many purposes; and whatever law develops the detail's *main characteristics*, doubtless causes it also to be modified to meet each minor use, in the degree of its relative importance. To illustrate with human experiences, the hunter's rifle, besides its main use, serves also at times the purpose of a balancing-pole, or even a club; and, carried over his shoulder as he goes away, it serves to show his family that there may be venison for dinner; yet its essential purpose is to *kill that venison*,—for this, nothing but a rifle would serve. In the same way animals' markings doubtless serve in various lesser degrees most of the purposes that have been attributed to them.

† Another good analogy is the universal human propensity to trust circumstantial evidence too much; to believe any accused person guilty, because the sin he is accused of is a common one.

demonstrably an increase of such potency of obliterative coloration as belongs to all gorgeously varied costumes, *and this at the very period when concealment is most needed.*

It is of great importance to understand that skill and strength are not all confined to predators. It is plain, upon any hypothesis whatever which recognizes the existing fitness of all forms of life to their uses, that this fitness is presumably just as great in the quarry's case as in the hunter's. The fleetness and alertness of the hare are a good match for the stealth and power of the lynx, etc., and the consequent balance between predator and prey is doubtless known to the instincts of each animal. The lynx's obliterative coloration just as much increases his dangerousness to the hare, as that of the hare adds to the lynx's difficulty in catching him.

Although inconspicuousness is merely an approach to indistinguishability (of course this positive term refers only to *occasional effects*), yet the practical workings of the two are worth considering separately. *Indistinguishability* enables predators to ambush their prey, and, on the other hand, it protects any quarry to the windward of which the predator may pass (if he is not trailing it). Mere *inconspicuousness* of the predator causes him to be less avoided by the animal he preys on, while for the prey it means a minimizing of the stimulus he gives to his enemy's rapacity. Also, at the ultimate moment both sides profit by showing as indistinctly as possible, so that the rapacious animal is harder to dodge, and the prey a fainter target to strike at. Sportsmen, insect-catchers, and tennis players will understand this. Again, in a very large class of cases the question is not whether the hawk, for instance, *can espy*, or the fox, *scent*, his game, but whether there appear to him, at the moment, sufficient advantages on his side to stimulate him to an effort such as has far more often failed than succeeded. Also, *a single instant of successful disguise suffices to protect an animal from a swiftly passing marauder*, a hawk, for instance. In a rapacious animal's case there must be an eternally shifting balance between *greed* and *inertia*. Doubtless a sufficiently strong incentive—a very obvious chance—might rouse even the most gorged of

hawks to attempt another capture; while, on the other hand, one that was starving, or whose young were, would achieve marvels of daring and power. Watch an *Accipiter* sitting amidst the usual abounding bird life of summer woods. You will often look long for any sign that the small birds fear him, or that he threatens them. One evidence that this balance of circumstances is what keeps the two classes of animals so peaceful in their general demeanor toward each other is to be found in the alacrity with which predatory animals rush to investigate an imitation of a bird's or mouse's cries of distress. So, too, a pickerel, after long listlessly watching your bait, with the barest signs of interest, will often seize it the moment it gets foul of a lily pad and seems in difficulty. Other things being equal, animals that hunt by sight (i. e., do the *whole thing* by sight, as hawks do in distinction from most rapacious quadrupeds) would try for the most conspicuous prey, just as a sportsman is almost irresistibly drawn to shoot at the best mark in a flock of birds—so much so, that, if he be a beginner, he may let them all go by, after swinging his gun upon one after another of them, unable to keep to the one first selected, when another has become more conspicuous.

Just as men who live amidst constant danger have powers of instantaneous action unknown to farmers and shopkeepers, so the hare and the deer have acquired in their hard school similar alertness and speed. In terms of the theory of natural selection, *the quarry has had just as many centuries to learn his part, as the predator to learn his*. Evidently, the hawk's nerves know this so well that, instead of wasting energy, they, so to speak, 'take into their own hands' the business of being ever ready to hurl him like lightning on a disabled or preoccupied victim.

Since we may assume that there *is* this closest balance between the respective powers of predaceous animals and their game, it follows that, in the long run, *smallest advantages will tell*. And if they *do* tell, the same process, whatever it be, that has adjusted moths to bark and made inchworms look exactly like twigs, must be *everywhere* at work, carrying each advantageous trait to similar perfection.

In the days of swordsmanship, there was little difference between fine fencers, yet *the best one* would, by the most delicate shades of superiority, get his sword through his opponent's ribs in one fight after another till all men feared him. That such things are more than luck is well known to life-insurance companies and army recruiters. Why do they take no chances, but, instead, *calculate averages*, and reject each applicant whose defects exceed the limit, even in cases where this applicant has a great many *chances* of continued health—where he *may* outlast sounder men? If war departments know that minute defects in individual soldiers will affect even a single campaign, how is it conceivable that, in the animal kingdom (if there be natural selection at all, or any corresponding principle), hundreds of thousands of years should leave any sifting unperfected, any slightest adaptation incomplete? All characters, barely noticeable by us, but which are in the long run of more use than harm, must develop.

This book demonstrates that the *colors, patterns, and appendages of animals are the most perfect imaginable effacers under the very circumstances wherein such effacement would most serve the wearer*. For any particular animal to be seen looking conspicuous means no more than that he is not at those moments looked at under the circumstances for which his concealing-colors are effective; and man's persistent misconception that bold patterns, etc., make the wearer conspicuous, is based on a psychological principle. Let us imagine one hundred butterflies of the same species within range of a naturalist's sight, and ninety-nine of them concealed from him by the effect of their bold patterns, while the hundredth happens to be noticed by him, and, of course, *identified* by all its attributes, bold pattern and all. What impression about the species has this naturalist gained through this experience? He carries away simply one more mental picture of a butterfly of this boldly patterned species, and mistakes its *specific recognizability* for *intrinsic conspicuousness*. The ninety-nine successful disguises have made no impression at all. So he goes on, accumulating a conviction that the species is conspicuous. He can tell you a long list of cases to prove it:—while the actual case

is, that for every one he saw there were as a rule scores, within range of his sight, *concealed* by the very patterns which he believes to make the species conspicuous! I had, lately, a chance to prove all these things upon a naturalist who believed, as has always been held, that "conspicuous" *patterns*, etc., make conspicuous *objects*. Of each species that he declared to be a conspicuous one I arranged either a stuffed specimen or a good imitation, and placed it full in his sight, out of doors, in the most natural of situations. And each time he was amazed at failing to find it conspicuous. In every case of a series of such tests, he discovered the specimen only after a more or less long search.

One case is enough to cite here. He declared a coral snake, with its red, black, and gold rings, to be "the most conspicuous object in Nature." I placed on bare ground some imitation snakes—one black, one scarlet, one gold, one earth-color, and *one good facsimile of a coral snake, with its bright scarlet, gold, and black rings, and the counter shading universal among snakes*, and invited him to look at them from a distance of about twelve yards. He saw at once *all but the coral snake*, and would never have known the latter was there had he not been told. Yet in this case he had been told *just where to look*, on a bare open space of flat ground.

I asked him if he still believed that a naturalist's eye takes in most of the coral snakes that come within its range in the complex scenery of the jungle! By such experiments *all* his beliefs on the subject were one by one confuted,—as, in the end, he most openly and generously acknowledged.

Concealing-coloration means *coloration that matches the background*. But since an object's background varies with the point of view, there can be no such thing as *complete, intrinsic inconspicuousness*. The *means* of objects' recognizability, no matter how they are colored or marked, is almost always their *silhouette*—i. e., their outlines in 'relieving' darker or lighter or differently colored against their background. If an object moves about—or, what amounts to the same thing, if the beholder moves about—the object is bound to silhouette in various ways against various backgrounds. If the

object moves about *outdoors*, in sunlight and in shadow, this versatility of silhouetting becomes extreme. Day's vast chiaroscuro can make the blackest objects 'relieve' bright against dark shadows, and the whitest objects 'relieve' shadowy dark against the light. Given a sufficient freedom of motion on the part of object or beholder, and, aside from changes in the object's own illumination, its backgrounds are bound to range through this whole scale of variations and contrasts, from *earth and its darkest shadows to sky and its brightest lights*. *Patterns on animals' coats are the utmost that Nature can do in opposition to these potent vicissitudes of silhouetting*. This is the point at which Darwin, Wallace, and others went wrong; and this in spite of the fact that their supposed "conspicuous" species *are*, doubtless, more easily detected, in the long run, than their "cryptic" species. It is true that if one sits still in a wild place one will usually detect more individuals of the so-called conspicuous kinds. *But this is because they are mostly arboreal or aërial species which a terrestrial observer is apt to see against a much wider gamut of background than that to which the so-called cryptics are subjected*. They are the ones that have to move about most freely in sunlight and in shade, and against all manner of backgrounds, from shining sky to the darkest forest shadows. *Their bold coloring, however, minimizes, not increases, their conspicuousness in this difficult situation*, where the more nearly monochrome so-called cryptics, adapted for "sticking close" to tree trunks or the brown ground, would be comparatively conspicuous. One animal most needs to escape observation from above, another from below, and others equally from all directions. It follows that some must be colored to match brown ground, some to match the sky, or sky and foliage, while some must have costumes combining these extremes; and just such wonderful adaptations, in highest development, prove to be universal. Animals, therefore, are *conspicuous* when seen *from any but the right viewpoint*—white sky-matchers showing bright against the ground, brown earth-matchers silhouetting dark against the sky, etc.,—with all the magic of their concealing-costumes lost. Again, it follows that we should be inclined to count *con-*

spicuous those species which *we* most commonly see against the wrong background. This is what Darwin and Wallace did,—and, failing to understand the effect both of pattern and of visibility through contrast and silhouette, they made the fundamental mistake of ascribing the conspicuousness to the very thing which opposes it. Their immense prestige has so riveted this error in students' minds as to have doomed the whole subject, hitherto, to confusion and neglect.

Naturalists repeatedly *experience* the difficulty of detecting brilliantly colored birds and strongly marked quadrupeds—commonly recording each case as surprising or inexplicable under the supposed circumstances, or sometimes manifesting a true apprehension of some one particular case, without seeing that they are dealing with a universal principle.*

Among the aboriginal human races, the various war-paints, tattooings, head-decorations, and appendages, such as the long, erect mane of eagle feathers worn by North American Indians,—all these, whatever purposes their wearers believe they serve, do tend to '*obliterate*' them, precisely as similar devices '*obliterate*' animals.

The color-relations of earth, sky, water, and vegetation are practically the same the world over, and one may read on an animal's coat the main facts of his habits and habitat, without ever seeing him in his home.

ABBOTT H. THAYER.

MONADNOCK, N. H., December 15, 1907.

* Here is a simple way to discover whether one has the full color sense necessary as a basis for studying oblitative coloration. If, like a multitude of people, one cannot see that shadows on an open field of snow, or on a white sheet, under a blue sky, are *bright blue* like the sky overhead, one will probably prove more or less defective in all color-perceptions. To prove that such shadows *are* sky colored, lay a colorless mirror on the snow in such a shadow,—its reflected sky will match the surrounding snow.

CHAPTER I

GENERAL OUTLINE OF THE BOOK'S SCOPE. THE "LAW WHICH UNDERLIES PROTECTIVE COLORATION" INTRODUCED

"PROTECTIVE COLORATION," with its achievement of the wonderful inconspicuousness of many wild animals in their native haunts, has been recognized since the earliest days of Natural History study. But the true character of this phenomenon has been ignored or misinterpreted, and the phenomenon itself has been observed only in one small corner of its wide field of action. It has waited for an artist, in the last years of the nineteenth century, not only to recognize the basic working laws of protective coloration, but to perceive that the many animals of supposed "conspicuous" attire are almost all colored and marked in the way most potent to conceal them.

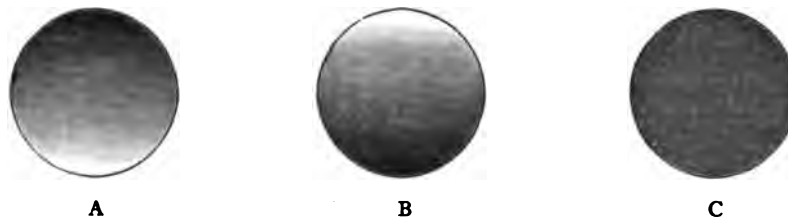
We will begin with an exposition of the long-ignored laws involved in such protective coloration as has been generally noticed, leaving to be developed in later chapters the revelation of its larger scope.

Since time immemorial, human hunters must often have been aware of the strange elusiveness of motionless deer in a brown landscape, or of hares or partridges squatting on the ground. Those who stopped to seek the cause of this, perceived that the deer or partridge looked almost exactly like the landscape or the ground in color, and were satisfied with this explanation; and thus was evolved that stock phrase of nature students, which has found a place in almost all books about animals, that these inconspicuous creatures are "colored like their surroundings." But it is our first task to show that this logical-seeming and universally accepted explanation is inadequate and misleading, and to vindicate the paradoxical-sounding statement that if crea-

tures *were* purely and simply “colored like their surroundings” they would not be inconspicuous at all. This has already been explained by articles in several scientific and popular magazines, but the explanation must be repeated here in full for the benefit of those who have not seen the former expositions of the discovery. What people commonly fail to perceive in connection with this matter, is that the exposition is really that of a discovery, i. e., of an indisputable optical fact, hitherto unnoticed, and not merely that of one more *theory*. It is the revelation of *how* animals’ wonderful inconspicuousness in their normal haunts, recognized for centuries but in its essence never understood, is really achieved. That is, not a description of any course of evolution or process of pigmentation, but the revelation of the manner in which the existent system of coloration renders animals nearly invisible on their native heath.

I will quote, with slight modifications, from the original article published in 1896, and from that published in *Nature* in 1902.

“The newly-discovered law in its application to animals may be stated thus: Animals are painted by Nature darkest on those parts which tend to be most lighted by the sky’s light, and *vice versa*. The accompanying diagram illustrates this statement.



“Animals are colored by Nature as in A, the sky lights them as in B, and the two effects cancel each other, as in C. The result is that their gradation of light-and-shade, by which opaque solid objects manifest themselves to the eye, is effaced at every point, the cancellation being as complete at one

point as another, as in C of the diagram, and the spectator seems to see right through the space really occupied by an opaque animal." In the *Nature* article this was reworded and emphasized as follows: "If an object be colored so that its tones constitute a gradation of shading and of coloring *counter* to the gradation of shading and of coloring which light thrown upon it would produce, and having the same rate of gradation, such object will appear perfectly flat;—retaining its length and breadth, but losing all appearance of *thickness*; and when seen against a background of color and pattern like its own will be essentially indistinguishable at a short distance. All persons who have seen the models which illustrate this, know that they prove it. Now, if this stands proved, the fact that a vast majority of creatures of the whole animal kingdom wear this gradation, developed to an exquisitely minute degree, and are famous for being hard to see in their homes, speaks for itself. It is plain that their color-gradation can no more escape effacing their look of solidity than the law of gravitation can escape drawing a projectile to the earth. This is so obvious, that one hears on all sides expressions of wonder that it was so long unnoticed. I may add that all persons of trained sight, such as artists, perceive it everywhere among wild creatures. Other people supplement their undeveloped sight-sense by their other senses, and if they *know* an animal *is* solid, think he *looks* solid.

"Let anyone look at a ball, or egg-shaped object, anywhere out of doors, and when he has recognized its shading, from its light side to its dark, try to so color it, where it stands, as to efface this shading. If he succeed, he will find that Nature has swiftly guided him through the same process which has taken her so long on the coats of animals, and that he has given the object the counter-gradation I speak of; and it will have dawned on him that so long as light makes its *one* gradation on objects, there is only the *one* way to neutralize it. In short, I simply prove that this arrangement of animals' colors is what so marvellously effaces them, and leave it to others to discuss the question whether concealment be a benefit to an animal, and whether the fact that it is a benefit be the cause of his being concealed. All who believe in Natural

Selection, however, will of course feel that this color-law is its work; and since it is so almost universally in use, and accounts, apparently, so almost exhaustively, for all the attributes of graded animal coloring, I believe it will ultimately be recognized as the most wonderful form of Darwin's great law."

The foregoing extracts together fully state the newly-revealed principle, which in its various elaborations is the foremost subject of the present book. But it may be well before going further to dwell at greater length on the simplest aspect of this fundamental principle.

No one who has studied animals in nature can have failed to notice either their frequent wonderful inconspicuousness, or the fact that ninety-nine per cent of them are dark colored on the back and light colored on the underside. On the other hand, even school children are daily taught that the only way to draw a representation of a ball or cylinder is to shade it from a bright central point or middle line to dark borders—or, if the object is to be shown in side view, under a top light, to shade it from very bright above to deeply dark below. Yet the obvious conclusion that the contrary gradation of shades, as it exists on the rotund bodies of animals, is the cause of their wonderfully unsubstantial appearance, has never been drawn till now, and even now is but slowly accepted by most people. This is because few people recognize the vast part played in the visible world by light-and-shade. As has already been said, the *known fact of solidity* suffices, to many minds, without any inquiry into the means by which that solidity is manifest to their sight. Light-and-shade, color, and line, are the three great factors of visibility. Line perspective enables the eye to judge to a large degree of the forms of objects, and the various distances of their different parts, especially in the case of large ones of elaborate shape, such as buildings; but the visibility of line is dependent on color, and still more on light-and-shade. I here use 'line' to mean the visibility of the boundaries of material surfaces and their parts. It is obvious that this is dependent on color, since if a monochrome flat surface is so placed relative to the eye of an observer that one of its boundaries is against another flat surface of precisely the same color, and similarly lighted,

that boundary will be invisible; and it is just as evident that it is dependent on light-and-shade, since two objects of like color can be differentiated, and two of different colors can be made to appear to blend together, by effects of shadow and light. Light-and-shade is more important than color, because it is primarily an attribute of form, while color is only secondarily so. The reader should look at his hand, or any other small object of elaborate form, and consider the factors of its appearance which enable his eye to perceive it, in its entirety and its details. The form and position of the various portions are revealed by the lines of perspective, and by the light-and-shade, that is, *the shadows on those parts which are most averted from the prevailing light, and the points of high-light on the reverse portions*. We have already seen that these main factors are interdependent on each other. Color, the third factor, plays a much smaller part. A projecting portion, for instance, may be of a different color from the rest, and will then be distinguishable from it by its color alone, but without the line and light-and-shade it would appear merely as a spot of color on the general surface—the projection would not show as such, except in so far as its peculiar color revealed its characteristic outline,—when, as in the case of the counter-shaded animal, the fact of its solid form would be mentally inferred, rather than actually *seen*, by the observer. On the other hand, there is the color difference between the surfaces which more directly catch the bluish sky-light, and the relatively orange-colored shadow-portions, etc., aside from other possible color incidents of reflected light; but these are secondary factors, since if the whole object were of a uniform neutral tint, and the *color* effects of the light were eliminated, the visibility of its various parts would scarcely be decreased. (Drawings in black and white, and photographs, are excellent exponents of this principle.) In just this way the form-variations of all solid objects are revealed to the eye—according to the simple law, that depressions lose light and are therefore darker, and elevations gain light and are therefore brighter; surfaces *averted* from the prevailing light being equivalent to depressions, and those turned toward it to elevations. It is, then, primarily by the *light-and-shade* on solid

objects, that the eye is made aware of their *existence*, their *main form*, their *position*, and all their *minor modelings*. Now, since this is the case, it follows that animals, *however colored*, would always be more or less conspicuous in their natural environment, and all the details of their form would be distinctly visible, unless their surfaces bore such an arrangement of light and dark shading of the colors as could counteract the shading which the descending daylight applies to their solid bodies. This counter gradation of shades, from dark mid-backs to white mid-bellies, is, as we have seen, precisely the system of coloration (*'Mimicry'*—*vide* Chapter II—*aside*) of almost all protectively colored animals.

The ghostly elusiveness of a counter-shaded creature's appearance is at its best under a diffused sky-light, such as that in the forest, or the open fields on a cloudy day, because no color gradation can adequately cope with the full and concentrated light of the sun itself, which produces sharply contrasted areas of light and shadow, rather than a graduated shading. Even in full sunlight, however, the light from the wide expanse of sky is still the principal factor. To understand this, the reader should compare the difference between a sunlit patch of ground and a neighboring one which is cut off from the direct sunlight, with the difference between the latter and the mouth of a deep hole which is cut off from both sun- and sky-light. The one is the slight difference between a sunny and a shady spot, the other is the vast difference between night and day. A patch of bright sky no bigger than the sun is far less brilliant, but the vast sum of such patches which the entire expanse of sky contains, yield a far greater light than the sun itself. (This is analogous to the principle of *sound*, which makes the sum of the concurrent echoes of a clap of thunder far louder than the initial sharp electrical report itself.) An animal's counter shading, then, is effective even on open ground on a sunny day, although the superadded direct sunlight interferes with the perfection of its working.

On this basis of the obliteration of the *light-and-shade* aspects of a solid creature, the most exquisite *color resemblances* to the creature's *background*

are achieved; on no other basis could they be achieved, or would they greatly avail the animal. (See, however, the definition of Mimicry in Chapter II.)

The reader who has assimilated what we have said thus far, is now in a position to perceive the fallacy of the statement, prevalent in former years, and still made by certain writers, that a protectively colored animal of the type described above escapes detection because, being of a dull-brown color like the ground and the bushes, it looks when it sits motionless like a clod or a stump—or some such inanimate thing. For clods and stumps are solid objects of a uniform tint, and manifest to the eye, by the laws of light-and-shade, not only their solidity, but all their smaller modelings. They are not inconspicuous, except in so far as their great abundance makes the eye inattentive to individual ones. The protectively colored animal, on the other hand, is, as it were, *obliterated* by his counter-gradation of shades, and in the cases where he escapes notice, it is by virtue, not of the eye's perceiving his solid form, and taking it for that of an inanimate object, but of its failure to recognize it as a solid object of any kind, seeming, if it rests on it at all, to see *through it to what is beyond*. For the animal looks at most like a flat plane interposed between its background and the observer; and since actual flat foreground-planes of this kind at right angles to the earth do not commonly exist in the woods and fields, the eye usually interprets the animal's surface as part of the scene, ground-plane or wood-mass, simple or compound, which lies beyond it. If these animals were merely brown or gray like clods and stumps, they would not be concealed, because their structural forms are too distinct, and the eyes of enemies are keen to detect their characteristic 'modeling' and outlines. On the other hand, a perfect shade-gradation, even of some rankly brilliant color, would go far toward concealing an animal, for he would still have no appearance of solidity; and any varied landscape, especially a sunlit one, even in the dingy temperate zone, is full of patches of brilliant color, as all artists know.*

* A large expanse of any strong color, as the green of the foliage, begets in its interstices and on its borders an appearance of its "complementary." It is partly for this reason, as an American

A striking revelation of how completely the inconspicuousness of counter-shaded creatures depends upon their counter shading, may be had even more easily than by experimenting with models, merely by holding such a creature *upside down*, in its normal lighting, and against its normal background. It will be seen not merely that its ghostly dimness has vanished, but that it is extraordinarily conspicuous—just doubly as conspicuous, in fact, as any stick or clod placed in the same position would be. For an inverted animal not only lacks counter shading, as a stick or clod does, but is even fully shaded the *wrong* way—brightest where it catches most light, and darkest where it catches least. No other conceivable arrangement of colors could make an object as conspicuous as this. Yet an animal held thus inverted is, materially, as truly “colored like his surroundings” as he ever was. It might be thought that such creatures are usually seen from above, so that their light-colored undersides are out of sight, and that only their *upper* parts, which always show, are supposed to be colored like their surroundings. To this there are two cogent answers. In the first place, many of these creatures, such as the various forest Grouse, are at their best when perched high above the ground, so that the under side is at least as fully exposed as the upper. In the second place, the colors of those which stay on the ground must surely serve as a protection against the ground animals, which move about on their own level, as much as against those which see them from above, as do hawks and men. This last is a very important consideration, with which we shall have to deal again later in the book.

In speaking of the elements of visibility, I have already referred to the fact that color—apart from light-and-shade—is a secondary factor in the visibility of the ‘modeling’ of solid objects, and have spoken of the tendency toward a *bluish* coloring of the more directly sky-lighted portions, and an orange coloring of the reverse ones. The working of this principle on the bodies of animals is very pronounced, and the counter gradation of their tones would ornithologist, Mrs. F. H. Eckstorm, has very truly said, that the gorgeous Scarlet Tanager is not conspicuous in the green woods.

not be perfect if it did not include a delicate gradation of actual *color*, from brownest above to bluest below, to cancel the effect of the bluish sky-light and shine on their upper surfaces, and the brownish shadow, with brown earth-reflections, on their lower. Cold white is usually required for the bright climax of the *shade* gradation, and cold white amply meets the *color* requirement also. It is likely that few but artists will feel the validness of our statement of this subtler element of the principle, although anyone can learn to see the existent gradation of 'color' on most counter-shaded animals.

The reader has now been given a fairly exhaustive description of the main elements of the new principle, which through its various windings and with its various remarkable concomitants we are about to follow into several branches of the animal kingdom. Among the lower orders, it is more or less largely supplanted by another great principle, namely, that of Mimicry, which we will define and differentiate in Chapter II.

Before closing this introductory chapter, however, we must give an account of the earlier, independent partial discovery of the principle of counter shading in the animal kingdom, by Prof. Edward B. Poulton, of Oxford University. Professor Poulton has been one of my father's most enthusiastic listeners, and is one of the few naturalists who have given proof of completely understanding the subject. In his introduction to my father's article in *Nature* he generously seeks to minimize the importance of his own partial pre-discovery of the principle.

The case is thus stated by my father in the above-mentioned article:

"Since publishing my papers in 'The Auk' for April and October, 1896, I find that Prof. Poulton perceived years before their appearance the power of a counter-gradation of light to make the round surface of a pupa appear flat, and in another case the power of light color in a depression to make the concavity disappear. In both of these cases he perceived the very *Law of Light-and-Shade* on which the fact of Protective Coloration rests, and recognized the fact itself in these instances. In his 'Notes in 1886 upon Lepidopterous Larvæ, etc.,' read April 6, 1887, he says (Trans. Ent. Soc. Lond., 1887, p.

294), 'Although the cleft (between the posterior part of the body of the larva of *Rumia crataegata* and the branch) is largely filled up, . . . a considerable furrow remains, but this is not apparent because of the light color of the fleshy processes, which prevent the attention from being directed to the shadow which would otherwise indicate the position of the groove. The processes, therefore, attain the object of softening the contact between the larva and its food-plant in a two-fold manner, by partially filling up the cleft and by neutralizing the shadow in the groove which remains. I have also noted the processes in the larva of *A. betularia*, and I believe that they are of very general occurrence in Geometræ.'

"His other case is to be found in his 'Notes in 1887 upon Lepidopterous Larvæ, etc.,' read October 3, 1888. He says (Trans. Ent. Soc. Lond., pp. 595-6), 'The most extraordinary thing about this resemblance (of the pupa of *Apatura iris* to a sallow-leaf) was the leaf-like impression of *flatness* conveyed by a pupa which was in reality very far from flat. Thus the length of the pupa was 30.5 mm.; the greatest breadth (dorso-ventral diameter) 11.5 mm.; the greatest thickness (from side to side) 8.5 mm.; . . . But exactly in these places, where the obvious thickness would destroy the resemblance to a leaf, the whole effect of the roundness is neutralized by the increasing lightness of these parts—a lightness which is so disposed as to just compensate for the shadow by which alone we judge of the roundness of small objects. (Much larger objects can be judged of by the change of focus, which becomes necessary as their near or distant parts are observed.) In shading the drawing of an object so as to represent roundness, the shade is made to become gradually less and less deep as the tangential planes represented come nearer and nearer to a right angle with the axis of vision. So here, the converse of shading—the whiteness neutralizing the shadow which shading is intended to represent—dies off gradually as the (representation of the) mid-rib is approached.

"The whiteness is produced by the relative abundance of white dots and a fine white marking of the surface which is present everywhere, mingled with

the green. The effect is, in fact, produced by a process exactly analogous to stippling.

“‘By this beautiful and simple method a pupa, which is 8.5 mm. from side to side in its thickest part, appears flat and offers the most remarkable resemblance to a leaf which is a small fraction of 1 mm. in thickness.’”

CHAPTER II

DEFINITION OF TERMS. ILLUSTRATIONS OF OBLITERATIVE COLORATION

BEFORE going further we must clearly establish and define the special descriptive terms which are to be used in the course of the book.

The term, "the law which underlies protective coloration," as applied to counter shading, was inexact, since "Protective Coloration" of course includes not only concealing-colors based on this newly disclosed principle, but many branches of the entirely different principle of Mimicry, as well.* A name even more to our present purpose than Protective Coloration, for the comprehensive meaning, would be one which should include all modifications of the bodies of animals, both those of form and those of color, whose object seems to be *visual deception of any kind*. This would make room for offensive as well as defensive mimetic resemblances, etc., and for the many curious cases of protective *form* modification, most common among the lower orders of animals. But we are to have so little to do with these partially extraneous principles that we need not discard the old and familiar term, Protective Coloration. Interchangeably with it, however, we shall use others somewhat more comprehensive, viz., Disguising Coloration and Disguising Costumes.

* Throughout our book we shall use the word Mimicry in a wider and perhaps looser sense than that in established use among zoölogists, and we herewith offer an apology for this innovation. In order to emphasize tersely the fundamental difference between 'Obliterative Coloration' and both the principles involving imitation of definite objects, which principles have been known respectively as Mimicry and Protective Resemblance, we have found it necessary to join the two last mentioned under the general head of Mimicry. Derivatively, the name is nearly as applicable to one as to the other, and the limiting it to the simulation of the colors and forms of animate creatures by those of other animate creatures, in contradistinction to the imitation of inanimate objects, is more or less arbitrary. The two phases are closely related, and for our present purposes must be considered as different branches of one principle, which can only be called Mimicry.



FIG. 1. Two bird-models, just alike except that the one on the left is counter-shaded, the other not, though covered uniformly with the very material of its background. This right-hand model, therefore, is *actually* as light below as above.



FIG. 3. Bird-models as in Fig. 1, but with the top-light cut off from the obliterated-shaded one, A.



FIG. 2. Obliterated bird-model, as in Fig. 1A, but inverted. (Somewhat side-lighted.)

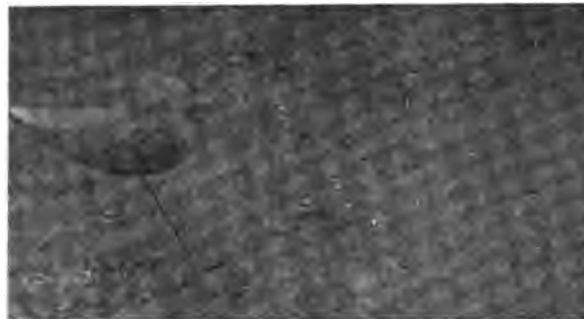


FIG. 4. Two bird-models as in Fig. 1, but out of doors against bare ground. The one on the right is obliterated, the other not.



FIG. 5. Two bird-models precisely as above save that the right hand one is still better 'obliterated.' The reader will have to take it on faith that this is a genuine photograph, and that there *is* a right-hand model of the same size as the other, unless he can detect its position by its faint visibility in Fig. 4.



Protective or Disguising Coloration, then, as we define it, falls into two main divisions; the one including *concealing*-colors mainly based on counter shading, and the other including Mimicry, in almost all its branches. As has already been explained, the goal of the former principle is the rendering animals *invisible* in their normal haunts. Mimicry, on the other hand, aims at *deceptive visibility*; it makes an animal *look like something else than what it really is*. It will be seen that the latter principle is open to unlimited variations of method and result, whereas the former, as we have proved, is in its main essentials strictly limited. There are innumerable kinds of solid objects for animals to simulate in appearance, but there is only *one* way to make a solid object in a natural lighting cease to appear to exist. Both these are principles of disguising costume, and both are protective, yet they are fundamentally unlike. It becomes necessary to find a fully adequate name for the stricter principle—a name less technical and more explicit than “counter gradation.” Obliterative Coloration is a phrase that will fit the general principle, and Obliterative or Counter Shading may be used as a stricter term for the essential root of it.

We have, then, *Obliterative Coloration*, and *Mimicry*, as the two main principles of Protective Coloration. Of the well-known and well-studied principle of Mimicry, we shall give but few examples, and these chiefly from among the lower orders. In the higher orders, it seems, as we have said, to play a very insignificant part.

Figs. 1-5 illustrate obliterative shading, pure and simple. Fig. 1 shows an obliteratively shaded artificial model, contrasted with a monochrome one which is colored precisely like the background, being covered with the very same material; Fig. 2 shows a counter-shaded model inverted, and Fig. 3 the two models in the proper position, but with the direct top-light cut off from the counter-shaded one.

Fig. 6 shows a Barred Plymouth Rock hen, a bird which completely lacks obliterative shading, photographed, out of doors, against a background made wholly of the flat skins of similar hens. A more striking demonstration of

the powerlessness of mere *similar colors* to conceal could hardly be devised. So, were it not for his obliterative shading, would the leopard or jaguar show up in the forest, despite his richly spotted forest-pattern.

Fig. 7 shows a pure white hen, photographed against a white cloth, another illustration of the ineffectuality of mere color-resemblance. The hen is conspicuously solid, her back showing *light* and her belly *dark* against the flat white plane of the cloth. Every part of her surface, in fact, except for a few mere *points* of transition, is either too dark or too light to match her background. A ptarmigan in winter plumage lacks the advantage of counter shading, and must needs lack it, since even the middle of its back has to be white to match its pure white snowy background, and nature can furnish nothing *lighter* than white feathers for the bird's underside. But the upward reflection from the snow itself goes far toward canceling the shadow on such animals. (See Figs. 8-10.) In the same way the reflection from bright sand coöperates with the delicate counter shading of desert animals, which are usually very light colored. Such creatures are also as a rule almost unmarked, and thus furnish good examples of the use of obliterative shading, pure and simple. It is on a delicate scale, however, since there is but a short range of shade between pure white and the delicate brown required to make the animals' backs 'coalesce' with the sand. Desert animals are of course habitually exposed to full sunlight, but the excess of shadow which the undersides of sunlit animals normally bear,* is in this case almost or quite counteracted by the light-reflecting power of the bright desert sand. Many forest animals, on the other hand, wear a slight counter shading at the *dark* end of the scale—that is, from some dark color to a very slightly lighter tone—because of the extreme diffuseness of the light in shady forest recesses, whose colors are mainly dark and rich. The need of extreme counter shading—from very dark to purest white—seems restricted mainly to high-standing animals which live in the open on *dark* ground. On such a one the direct sky-light makes its full graduated shading, and the shadow of the undersides

*See p. 18, Chapter I.



FIG. 6. Plymouth Rock hen—a bird which lacks counter-shading—against a flat background of Plymouth Rock hen skins, demonstrating the same thing as Fig. 7.
Photographed from life.



FIG. 7. White fowl, lacking counter-shading, against a flat white cloth. To show that a monochrome object can not be 'obliterated,' no matter what its background.
Photographed from life.



FIG. 8. Rocky Mountain White-tailed Ptarmigan in winter plumage, on snow, and favorably lighted for inconspicuousness. Rotundity as dimly apparent as is possible without counter-shading.

Photographed from life by Edward R. Warren.



FIG. 9. Rocky Mountain White-tailed Ptarmigan, in winter plumage, off snow. Their rotundity, revealed by their lack of counter-shading, is marked. But they may still pass for *lumps* of snow.

Photographed from life by E. R. Warren.



FIG. 10. Rocky Mountain White-tailed Ptarmigan in winter plumage, on snow, but unfavorably lighted for inconspicuousness.

Photographed from life by E. R. Warren.

1

is not alleviated by upward reflection; while the highly illuminated back has to be of a very dark tone to coalesce with the dark earth, rock, or whatever it may be that forms the animal's normal background.

These examples serve to illustrate the law, almost or quite infallible, that the range and scale of an obliteratively colored animal's counter shading depend on the ratio of the average brightness above it to the average darkness beneath it, in its normal haunts. Thus, to recapitulate, we find on sandy deserts birds, mammals, and reptiles counter-shaded from sand-color to white, while on dark-colored open ground we find them shaded from very dark to white. (Of this last class the smaller Wood Sandpipers (*Totanus*), which live on muddy stream and pond banks, are excellent examples. So also, in a cruder form, are some of the Oyster-catchers (*Hæmatopus*) and Stilts (*Himantopus*), whose counter shading consists of two tones only, black and white. Among mammals, examples are the darker-backed hares, deer, kangaroos, etc., which live more or less fully exposed to the sky-light on rather dark ground.) Where the sky-light is intercepted and diffused by foliage or other natural obstructions, as on the ground under grasses, bushes, etc., on marsh-land under reeds and rushes, and, most of all, in the forest, we find many rich or dark-colored animals with a weak obliterative shading (one, namely, whose bright climax comes more or less short of white, being even in some cases but slightly lighter than the tone of the back). Many of the forest-inhabiting passerine birds of Europe and America wear this form of counter shading, as do also certain forest grouse, as well as squirrels and other mammals; while among tropical birds it is well represented by many green parrots and parrakeets, etc., and also by many brown species that inhabit the gloomy interiors of the great forests. Some of the ground sparrows, and the rails, are good examples of the grass and swamp forms, while the female of the European Blackbird (*Merula*), and the North American Catbird (*Galeoscoptes*) may be cited as examples of the thicket-haunting form among familiar birds. This indisputable fact, that animals tend to be *dark* in thickets and dusky forests, and *pale* on the glaring desert, and on ocean beaches, is a

complete refutation of the theory that the counter shading is due to the *tanning* effect of light. On the other hand, the idea that the paleness of desert creatures is due to *bleaching*, is equally well answered by the fact that their *shadowed undersides* are still the lightest, as in the case of almost all other animals.

Figs. 11-13 show photographs of the skins of various birds and mammals, split longitudinally through the lower median line, and spread out flat. This is a simple and adequate way of exhibiting the exact character of the obliterative shading of animals. The names of the species thus represented are given under the pictures. It will be seen that some beasts which are usually considered practically monochrome, such as the Mink (*Putorius vison*), have in reality a slight counter shading. (See footnote, p. 123.)

Pictures of protectively colored wild birds and mammals *in situ* cannot be really true to Nature if they represent them as having the light-and-shade of normal solid objects—a fault usually committed by illustrators, who study them in unnatural situations, such as the cages of a menagerie, or other places where the illumination fails to cooperate with their counter shading. These paintings of ours (grouse, rabbit, snake, caterpillars, etc.) are intended as examples (outside the field of photography) of *true* animal illustration—rendering instead of defeating the wonderful obliterative effects of their counter shading.*

Of course so new a lesson cannot be learned all at once by the world at large. But when the truth on any subject has once been started, it cannot fail gradually to supplant the previously existing errors. It will be many

* Japanese and Chinese art almost entirely dispenses with light and shade, dealing solely with line and color. Japanese pictures of birds and mammals, therefore, represent, approximately, the animal's actual color tones, quite irrespective of shading. A white belly, for instance, is painted as bright as a white back. Thus these Oriental renderings of animals are actually, in one sense, more realistic than the Occidental, because by their complete lack of shading they approximate the wonderfully unsubstantial look of the birds and beasts in Nature. An object which shows lighter on its lower border than its upper, under the light of the sky, cannot possibly look *solid*. It looks at most like a party-colored flat (or concave) surface, rather than a rotund body.



FIG. 11.



FIG. 12.

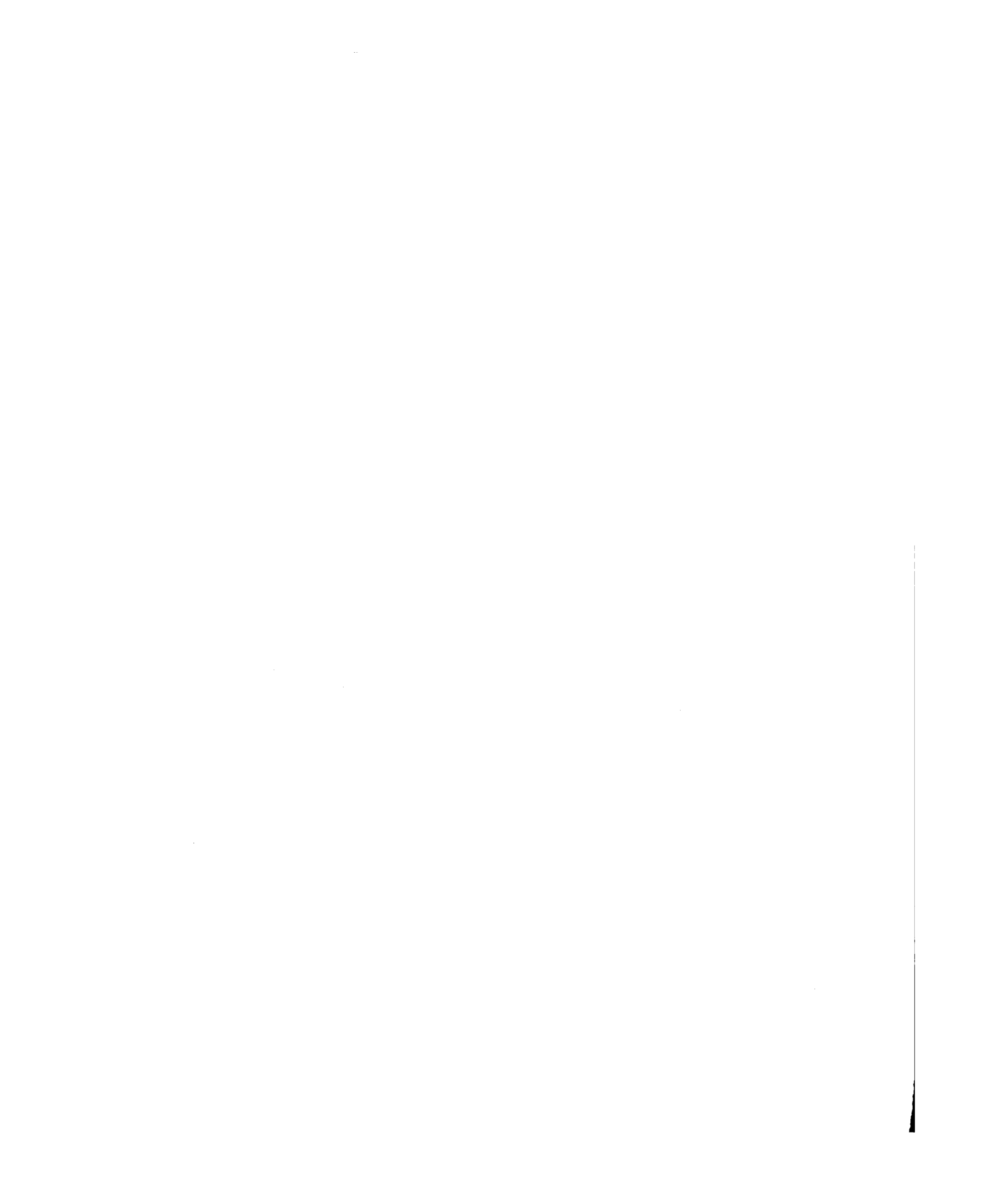
FIGS. 11 and 12. Mammals' skins spread out to show obliterative shading.

FIG. 11. Spotted Seal (*Phoca ritulina*.)

FIG. 12. Cotton-tail Rabbit (*Lepus floridanus transitionalis*.) [CL. above.]



FIG. 13. Birds' and mammals' skins spread out to show obliterative shading, continued. The species are as follows: Beginning above, left, Blue Jay (*Cyanocitta cristata*), Tree Swallow (*Tachycineta bicolor*), Pine Grosbeak (*Pinicola enucleator canadensis*, female), Common Chipmunk (*Tamias striatus*), Mink (*Putorius vison*), English Sparrow (*Passer domesticus*, female), Lesser Whitethroat (*Sylvia curruca*), two kinds of shrew-mole, names (?) jumping mouse (*Zapus hudsonius*, stuffed skin, side view), Am. Siskin (*Spinus pinus*), Gray Squirrel (*Sciurus carolinensis*), Muskrat (*Fiber zibethicus*), and sharp-shinned Hawk (*Accipiter velox*, young female).



years, no doubt, before a drawing with conspicuous light-and-shade of a live sandpiper or rabbit in Nature is looked upon as an absurdity—and yet that time must surely come.

Having considered obliterative shading, pure and simple, we will now advance to the next stage in the study of *obliterative coloration*, namely, the use of *markings* on counter-shaded animals.

The first few chapters will deal chiefly with artificial models.

CHAPTER III

FIRST PRINCIPLES OF THE USE OF MARKINGS WITH OBLITERATIVE SHADING

THE need of markings is a natural concomitant of the principle of obliterative shading. When an unmarked solid object in a given lighting has been reduced to a perfectly 'flat' monochrome by counter shading, so that it lacks all visible attributes of solidity, it may be quite undistinguishable, *provided that its background is of a similar monochrome flat tint*. Such is the case in Fig. 14. The solid model is almost undistinguishable, seeming merged into the flat plane of the cloth-covered board, which in reality is several yards behind it.

Complete 'obliteration' has taken place; for the model, having no distinctive light-and-shade, color, or surface character, is as it were *absorbed* into its background, and the space in which it stands seems occupied by empty air. But if we now apply a pattern to the background, as in Fig. 15, the case is changed. Though still unsubstantial-looking, and very inconspicuous, the model is clearly discernible as an *interruption of the background-pattern*. If this pattern is small and regular, as in our figure, the whole of the unmarked object's characteristic outline may be traced against it, and by the process of mental inference already alluded to, the observer will recognize it, in spite of its ghostly flatness, as a solid body *between* him and the background-plane. But behold the effect of applying a like pattern to the model also, as in Fig. 16! It immediately recedes again into the flat plane, and the eye loses it even more surely than before, because its likeness to its background is now positive and graphic, at many points.

The foregoing figures illustrate the simplest form of the use of markings in coöperation with obliterative shading. The next thing for us to consider



FIG. 14. Obliteratively-shaded bird-shaped model against plain background. (Defective photograph, retouched. The model might show even less, in reality. Cf. Figs. 4-5.)



FIG. 15. Bird-shaped solid model, obliteratively-shaded in full, and correctly lighted, but revealed by its blank silhouette against a spotted background. Photograph.



FIG. 16. Bird-shaped, obliteratively-shaded model, as in Fig. 15, but concealed by the addition of spots like those of its background. Photograph.



FIG. 17. Spotted, obliteratively-shaded bird-model, as in Fig. 16, but wrongly lighted. This picture shows the *dependence* of the part played by pattern in the obliteration of leopards, zebras, etc. Without counter-shading, these animals would look conspicuously solid, despite their patterns.



is the matter of pattern *perspective*. The elucidation of this will mark another step in the differentiation of obliterative coloration from all forms of mimicry. For it will show that not an exact reproduction of the actual background-pattern, but a picture of that pattern as it looks when more or less altered and refined by distance, is essential to the concealing of an object. Or, in other words, that the object's obliteratively-shaded surface must bear a *picture of such background as would be seen through it if it were transparent*. The diagram, Fig. 18, represents a flat, bird-shaped model, vertically placed, seen against a horizontal background. The background-pattern is supposed to be actually uniform throughout, but diminished to the eye as it recedes on the horizontal plane. The model, vertically interposed between the eye and this receding ground-plane, must, for concealment, bear a pattern graduated from larger on its lower borders to smaller on its upper. For the highest parts of the model are seen against the most distant and therefore most diminished portion of the uniform background-pattern—and *vice versa*. Furthermore, the markings of the background, being on a receding plane, are *foreshortened* throughout, and this effect also must be imitated on the model.

These diagrams and photographs will serve to illustrate, in a crudely simplified form, some of the main principles of obliterative pattern which prevail in Nature. Instead of one unvaried pattern on a single plane, however, Nature furnishes backgrounds of rich diversity. Mud, grasses, pebbles, bushes, tree-trunks, branches, leaves, living and dead, and vistas amid vegetation to the bright sky beyond—these, all of them subject to endless variations of comminglement, of distance, and of lighting, are a few of the numberless details of the backgrounds against which ground-haunting animals are seen. To achieve the highest degree of inconspicuousness, these animals must wear, superadded to their obliterative shading, yet in the main conforming with it, a sort of compound picture of their normal backgrounds—a picture seemingly made up by the averaging of innumerable landscapes. Further, this landscape-picturing must be suited variously to different portions of the animal's surface. The top-planes, being seen in full only against the nearer ground,

must bear a larger pattern than the sides (see the second diagram, Fig. 19), which are seen against more distant ground or forest landscape, with details reduced and altered by perspective; and the highest portions of the side-planes, e. g., the sides of the animal's head, being seen, in the long run, against the most distant backgrounds, must have the finest pattern of all. Coöperant with these principles is the fact that the pattern looks different on *receding* planes of the solid object. Thus in the side view all that shows of the necessarily coarser top-pattern is so refined and narrowed by perspective that it is fully equivalent to the actually finer pattern of the sides. In the reverse case, the side-pattern scarcely shows at all.

Nature's achievement of this ultimate perfection of obliterative coloration, on *birds*, is the subject of our next chapters.



FIG. 18. Diagram showing the picturing of perspective by animals' patterns. The bird is supposed to be vertically placed, and looked somewhat *down* upon against a uniformly patterned horizontal ground-plane.



FIG. 19. Diagram supplementing Fig. 18, showing the coarser *back*-pattern, required to match the ground-pattern un-foreshortened and almost undiminished, as when seen from directly above.



FIG. 21. Shows particularly well the head-markings' picturing of a shadowed cavity crossed by lighted twigs or grasses.

FIGS. 20-21. American Woodcock on its nest; showing the working of the wonderful obliterative picture-patterns, founded on counter-shading.

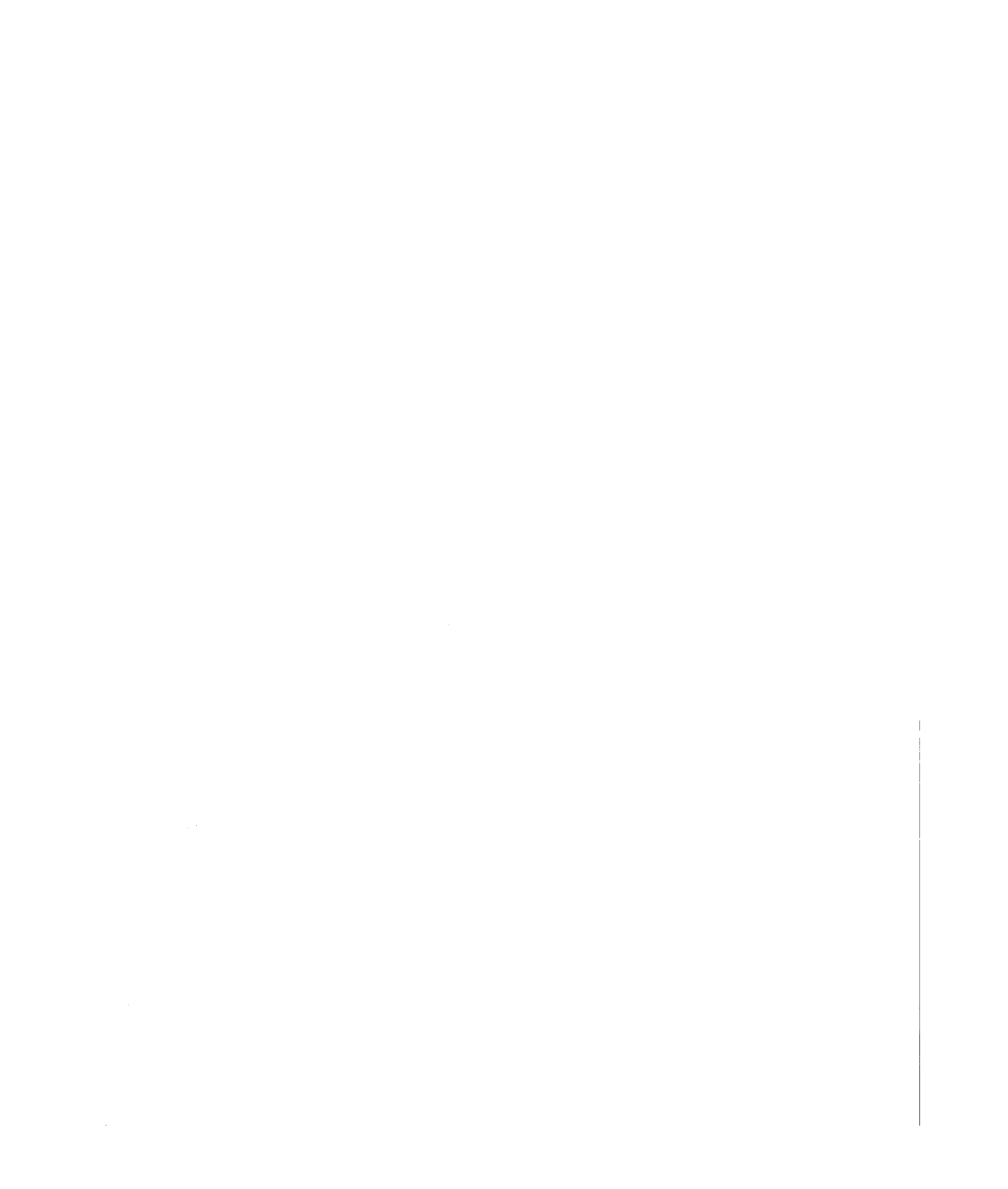




FIG. 22. American Woodcock (*Philohela minor*) on its nest. Counter-shading and picture-pattern.
 Photographed from life by (1)



FIG. 23. Dead Woodcock passed much like the nesting bird in Fig. 22, but with its underside and side tinted brown, as dark as the bark. The bird is now revealed by its lack of counter-shading.
 Photographed out of doors.



A



B

FIG. 24. A and B. Dead Woodcock on its side: A, back view; B, breast view; both conspicuous because in wrong positions for the normal working of the obliterative shading.
 Photographed from dead birds out of doors.

CHAPTER IV

BACKGROUND-PICTURING ON OBLITERATIVELY-SHADED BIRDS. FIRST TYPE, PICTURING OF THE LARGER DETAILS OF THE NEARER GROUND, ON TERRESTRIAL BIRDS

HEREWITH we leave the arid field of demonstration with artificial models, and launch into the wonderland of actual Nature. If we compare the numerous cases of evident background-picturing on the bodies of obliteratively-shaded birds, we find that they are clearly separable into several main classes or divisions. Many of the species, for instance, have a wonderfully minute and intricate pattern, while others, almost equally famous for their 'invisibility,' are marked in a much simpler and more blotchy way. The finely-patterned class is again divisible into two very different branches, as we shall see later on. This chapter, as the heading indicates, is to be devoted to the more blotchily-marked type of pattern-bearing 'Invisibles.' The best examples of this type are terrestrial birds which live among fallen leaves and sticks, etc., or among weeds and grasses, patches of mud, and pools of water. Preëminent among them are the Snipes and Woodcocks (*Philohela*, *Gallinago*, etc.),—Figs. 20–26.

The American Woodcock (*Philohela minor*) is a beautiful representative of the class. See Figs. 20–22, reproduced from photographs of live Woodcocks in Nature, and Figs. 23–24, which show photographs of a dead Woodcock against a normal background, but with its oblitative shading variously upset. In Fig. 24A, the bird is on its side, with its back toward the spectator. Thus the largest expanse of its pattern is exposed to view, yet it completely fails to obliterate, chiefly because it is no longer aided by a proper light-and-shade gradation. Fig. 24B shows the same bird with *under* instead of *upper* side exposed—in which position it is of course even more conspicuous. Fig.

23 shows the bird, with the general shade of its back artificially extended over its sides and belly, posed to simulate as nearly as possible the attitude of the live bird on its nest represented in Fig. 22. The contrast between the two, as to conspicuousness, is most pronounced.*

No clearer elucidation could be devised of the pattern-principle in question than is furnished by the photographs of live Woodcock and Snipe (Figs. 20-22 and 25-26). The imitation of the larger details of the squatting bird's near background is exquisitely perfect, particularly in Figs. 22 and 25. Dead leaves, twigs, and grasses, variously disposed over shadow-holes, in a near view, are the main components of the pattern-pictures which such birds wear. Because they are strictly terrestrial and rather sedentary, in time of danger usually squatting motionless on the ground, and allowing enemies to approach them very closely before they fly, they are almost always seen against a comparatively near portion of the ground-plane, and hardly ever against a highly diversified forest landscape. Hence a picturing in slight reduction of the simpler ground-pattern of leaves and twigs, etc., common to all the bogs and coverts which these birds inhabit, is all that is needed for the complete 'obliteration' of their counter-shaded bodies.

Many other examples of this class of background-picturing could be cited, but the ones already given will suffice. That most beautifully patterned bird, the European Woodcock (*Scolopax rusticola*), belongs in a distinctly different class, and will be considered later on.

* These four pictures (Figs. 22-24B) are reproduced from the article in the *Annals* mentioned in our preface.



FIG. 25. Wilson's Snipe on its nest; 'obliterated' by counter-shading and picture-pattern (representing sticks, grasses, etc., with their shadows, at various distances.)

Photographed from life by Herbert K. Job.
Here reproduced by courtesy of Houghton, Mifflin & Co.



FIG. 26. Jack Snipe (*Gallinago caelestis*). Still more specialized 'picturing' of straight, bright sticks (or dead reed stems, or broad grass-blades) and shadows. [Cf. the Chipmunk, Figs. 13 and 93.]

Photographed from life by Cherry and Richard Kearton.
Courtesy also of Cassell & Co.





FIG. 27. Nesting Whip-poor-will. [Cf. Fig. 28.]
Photographed from life by Herbert K. Job.



FIG. 28. Whip-poor-will (*Antrostomus vociferus*) on its nest. Near-ground-'picturing' patterns of the minutest type, founded, as always, on obliterative shading.
Photographed from life by Rett E. Olmstead.

CHAPTER V

BACKGROUND-PICTURING ON OBLITERATIVELY SHADED BIRDS, CONTINUED.
SECOND TYPE,—INTENSELY ELABORATE PICTURING OF THE MINUTE
DETAILS OF THE NEAR GROUND, ON TERRESTRIAL BIRDS

THERE are two main types of intricate-pattern background-picturing, as there are two classes of minute forms and markings in field and forest landscape. The one consists of the actually minute markings of the various inanimate objects, such as leaves, logs, sticks, stones, grasses, etc., seen at very close range; and the other of the cruder forms of large objects and groups of objects, such as tree-trunks and branches, and sky-vistas, reduced and refined by distance into a delicate pattern.

Marvelously fine and intricate patterns, rendering with almost microscopic minuteness the aspect of dead leaf and mossy log surfaces, seen at extremely close range, with an admixture of somewhat more distant ground-vista picturing, are worn by such birds as the terrestrial forest Goatsuckers (*Caprimulgidae*), which are almost unique among birds in their evident extreme dependence on obliterative coloration. Squatting motionless on or near the ground in the depths of shady forests, they take wing only as a last resort, when *almost trodden upon* by an enemy. In conformity with this habit, their obliterative pattern is developed to a point of minutely detailed realism quite beyond that of such well-concealed ground birds even as the American Woodcock. It is as if the Woodcock wore an adequately true facsimile of the main effect of its dead leaf and stick background, with the smaller markings of these objects largely omitted, while the Goatsucker wears a similar pattern-picture carried out to the last degree of finish, with all possible minute details faithfully represented. The intricate bark- and lichen-pattern of the surface of a fallen log, the reticulations of dead leaves,—all the innumerable delicate mark-



FIG. 27. Nesting Whip-poor-will. [Cf. Fig. 28.]
Photographed from life by Herbert K. Job.



FIG. 28. Whip-poor-will (*Antrostomus vociferus*) on its nest. Near-ground-'picturing' patterns of the minutest type, founded, as always, on obliterative shading.
Photographed from life by Rett E. Olmstead.

CHAPTER V

BACKGROUND-PICTURING ON OBLITERATIVELY SHADED BIRDS, (CONTINUED).
SECOND TYPE,—INTENSELY ELABORATE PICTURING OF THE MINUTE
DETAILS OF THE NEAR GROUND, ON TERRESTRIAL BIRDS

THERE are two main types of intricate-pattern background picturing, as there are two classes of minute forms and markings in field and forest landscape. The one consists of the actually minute markings of the various inanimate objects, such as leaves, logs, sticks, stones, grasses, etc., seen at very close range; and the other of the cruder forms of large objects and groups of objects, such as tree-trunks and branches, and sky vistas, reduced and refined by distance into a delicate pattern.

Marvelously fine and intricate patterns, rendering with almost microscopic minuteness the aspect of dead leaf and mossy log surfaces, seen at extremely close range, with an admixture of somewhat more distant objects picturing, are worn by such birds as the terrestrial forest *Ceryle alcyon* (*Ceryle alcyon*), which are almost unique among birds in their evident extreme adaptation on obliterative coloring. Spenting their lives in the depths of shady forests, they take wing only as a last resort, when almost sudden upon by an enemy. In conformity with this habit their obliterative pattern is developed to a point of minutely detailed precision quite beyond that of such well-concealed ground birds even as the European Woodcock. It is as if the Woodcock were an intermediary between the main effect of its dead leaf and stick background, with the smallest markings of these objects largely omitted, while the *Ceryle* wears a similar pattern-pattern carried out to the last degree of fineness with all possible minute details minutely represented. The intricate background picturing of the surface of a fallen log, the ramifications of leafy grass, and the numerous other minute

ings discernible upon close scrutiny of the forest ground, together with the larger pattern formed by groups of slightly more distant leaves and twigs, etc., with their high-lights, their middle tones, and their dark shadows,—all these things, variously reduced by perspective, are clearly suggested to an appreciative observer by the marvelous patterns of the forest *Caprimulgidae*. The fact that none of these detail-picturings is so patently realistic as to be appreciable to everyone when the bird is seen away from its natural environment, is part of the very marvel of the thing. Thanks to some process * which in its visible results has amounted to something like an *averaging* of all the normal backgrounds, against which, from aboriginal times, the animals have been seen, they bear a pattern precisely similar to none, yet amply fitting all. This effect of perfect *averaging* or *compounding* is one of the most beautiful and essential parts of the obliterative principle. (In certain cases, which will be considered later on, an animal's background is subject to so little variation that a more simple and single imitation of absolute details is possible.)

Though fully developed, the obliterative shading underlying this pattern-system of the goatsuckers is slight in range, conformably to the diffuseness of the top-light in deeply shaded woods, which these birds inhabit during the day. True obliterative coloration perhaps makes its nearest approach to mimicry among animals bearing this form of pattern. For while the counter shading as well as the character of the markings proves the case to be one of obliteration, or *merging with the background*, yet the apparent extreme nearness of some of the pictured details, which in certain views will even 'coalesce' perfectly with the markings of the *very object* on which the animal is sitting, such as a stone or mossy log, gives the phenomenon, in part, close kinship with the exact mimicry of surface-detail on an animal whose protection is the simulation, with full appearance of solidity, of a single inanimate object. It is furthermore undeniable that a finely-patterned bird such as we have been describing does occasionally pass for an excrescence of the log or rock on which it sits. This may be the case, for instance, when it is seen in

* We ourselves attribute all such work to natural selection, pure and simple and omnipotent.



FIG. 29. Nighthawk—a percher in the open, on lichen-freckled rocks, tree boughs, etc. Near-ground-picturing of the minutest type (based, of course, on obliterative shading.)
Photographed from life by J. E. Seebold.



FIG. 30. Nesting Nighthawk. [Cf. Fig. 29.]
Photographed from life by Ora K. Knight.



FIG. 31. Ruffed Grouse walking. 'Obliterated' by its highly-wrought picture-pattern, based on complete obliterative shading.
Photographed from life by James R. Miller.



FIG. 32. Nesting female Ruffed Grouse.
Photographed from life by James R. Miller.

full side-contour against an unfavorable background, especially if its markings do not clearly show. For, we repeat, these markings, though pictures of comparatively near details, are still *pictures*, in the sense of representations of patterns *beyond* the animal, and *not* exact facsimiles of the surface-markings of any object. It must be remembered that a large class of the enemies of such a bird, namely, the terrestrial carnivorous quadrupeds, which approach it on its own level, usually see it against a more distant background than do we tall bipeds who look *down* upon it. In accordance with this fact, it will be found that there is more than one would at first suppose of the element of distant background picturing in the side-markings of most terrestrial birds. But even if it is merely the thickness of an animal's counter-shaded body which habitually intervenes between its exposed side and the seeming background pictured by its markings, the principle is not *mimetic*, according to our nomenclature. To complete the statement, we must add that no animal bearing a full obliterative shading can, under normal conditions, pass for some other kind of solid object, but must appear either as a flat plane, or as merged into the scene behind it, whether near or far,—the smallest possible extent of its apparent retrocession being a distance corresponding to the thickness of its own body; but in order that it may completely undergo such 'obliteration' the pattern which it wears must always be smaller than the actual pattern of its background.

Figs. 27-30 need no explaining in the text.

CHAPTER VI

BACKGROUND-PICTURING ON COUNTER-SHADED BIRDS, CONTINUED. THIRD TYPE,—PICTURING OF THE MORE DISTANT BACKGROUND ON PARTIALLY ARBOREAL BIRDS

IT is obvious that high-standing and tree-perching birds tend to have more distant 'backgrounds' than do those that squat on the ground, and that in many cases the only pattern which could adequately cooperate with their obliterative shading would be one which should 'coalesce' with a highly diversified forest-interior landscape. A landscape, that is, made up of tree trunks and branches, near and distant, the interminably various criss-cross pattern of the smaller twigs, stretches of sunlight-dappled ground, glimpses of sky, etc.,—or, in other words, the second type of intricate pattern named in the preceding chapter.

Such a pattern exists on many birds, and when, as in nearly all the cases, it is to some degree commingled with a representation of the nearer details of the ground-plane, to suit its wearer's partially terrestrial habits, it marks the very consummation of the obliterative principle. Certain forest grouse, such as the *Bonasa umbellus* or Ruffed Grouse of North America, and the Hazel Grouse (*Bonasa betulina*), of Europe, are perfect examples of this type. The colored plate represents a cock Ruffed Grouse, against a variegated forest interior. This picture, as stated in the Preface, was painted from woodland photographs, etc., and from a stuffed grouse in a house-lighting artificially arranged to suit the bird's counter shading. Notice his complete lack of light-and-shade indicative of solidity—by which lack his beautiful ground-and-forest markings are enabled to 'coalesce' effectively with those of his background. Such—or even more magically obscure—is the aspect of a live Ruffed Grouse in a naked tree, which the eye of the hunter scans in vain at-

EXPLANATION OF PLATE II

MALE RUFFED GROUSE IN THE FOREST.

Painted by Gerald H. Thayer

1 2 3 4 5 6 7 8 9 10 11 12

THE BIRCH GROVE IN THE FOREST

THE BIRCH GROVE IN THE FOREST



tempt to detect its ghostly form. The bird is in plain sight, but invisible—such is the wonderful power of full obliterative coloration. Nature has, as it were, used the bird's visually unsubstantialized body as a canvas on which to paint a forest vista. In this there is nothing of mimicry, as we define it. Mimicry uses the solid aspect of an animal's body, modified in form and color, to simulate some other solid object. But vista- or background-picturing, based on the complete obliteration of the animal's solid aspect, which causes its actual form to pass for an *empty space*, is a widely different principle. Even in the terrestrial moments of the Ruffed Grouse's life, it is usually seen against more distant backgrounds than are the Goatsucker and Woodcock, because it largely lacks the squatting-habit, except in the case of the young, or the female sitting on her eggs. (See Figs. 31-33.) Noteworthy in this connection is the fact that the markings of the sexes are decidedly unlike. In the female, the most critical portion of whose life is probably the annual three weeks' brooding on her ground nest, the blotchy near-ground pattern predominates over the forest-vista pattern; whereas in the male it is just the other way. It is difficult or impossible to distinguish the two styles of pattern absolutely in either case. But they are so adequately commingled, in one or the other predominance, that, however the bird is placed, some portion is almost certain to coalesce perfectly with its background; and with this keynote of complete obliteration the remainder of the pattern amply serves its purpose. Indeed, not even this degree of actual immediate 'matching' is necessary for the bird's concealment. His costume is a sort of patchwork of pictures, subtly intermingled, each an epitome of some particular type or detail of woodland scenery. Such details and bits of landscape are *characteristic of the place in general*, and even when those furnished by the grouse's pattern are unmatched by any in his immediate background he is not apt to be revealed. Only an artist, perhaps, can rightly appreciate the profound and perfect realism of these background-pictures worn by birds and other animals. Just as a good caricature drawing of a man looks in one sense more like the man than the man himself, so, in a far more high and wonderful

degree, do these pictures on animals' coats exceed the verisimilitude of the actual scenes they imitate. They have been compounded and epitomized and clarified till only pure, essential typicality remains. The difference may be stated tersely thus: On the one hand, we see *a stick, a leaf, a web of twigs over the sky*; on the other hand, we see *stick, leaf, web of twigs over sky*. Just as in great human art, but far more essentially and surely, the trivialities and chance individual abnormalities have been eliminated, or subordinated to the scheme of ultimate, impartial typicality. To learn, then, the purely characteristic colors and light-and-shade effects of leaves and sticks and stones and other parts and types of natural scenery, we should look not at the scenes themselves, but at the animals whose patterns picture them. The essential realism of these pictures is such as the keenest artist among men could never hope to match. Nay, for Nature herself has made them—Nature herself has discovered and applied, to a point utterly beyond human emulation, the art of painting pictures.

Let us recur once more to the Ruffed Grouse. The transverse barring of its breast and flanks, a form of marking common to a majority of the larger birds inhabiting northern forests, closely imitates the appearance of horizontal branches seen at rather short range. Such branches are a very important feature of coniferous forest scenes. When this barring occurs on the underside of a forest bird, it is almost invariably continued by a series of spots on the outer webs of the primary wing-feathers. These spots become confluent when the wing is folded, and thus the large-branch-picturing is made to extend almost uninterruptedly across the bird. (See the colored plate. Our grouse, however, was rather weakly barred underneath.) The beautiful oval-spotted pattern of the Ruffed Grouse's rump is somewhat hard to analyze. It plays a small part in the side views, but has great prominence when the bird is seen from above. More than anything else, perhaps, it looks like a several yards distant patch of pine-needle-covered ground, peppered with small dead leaves, such as those of the Checkerberry (*Gaultheria*), or dappled with broken flecks of sunlight.



FIG. 33. Ruffed Grouse brooding. This picture admirably illustrates a phase of ground-matching by the Ruffed Grouse's most beautiful and elaborate 'obliterative' picture-patterns.
 Photographed from life by George C. Embury.



FIGS. 34-35. Dead Ruffed Grouse laid on its side. Fig. 34, breast view; Fig. 35, back view; both conspicuous because in wrong positions for the normal working of the obliterated shading.
 Photographed out of doors.

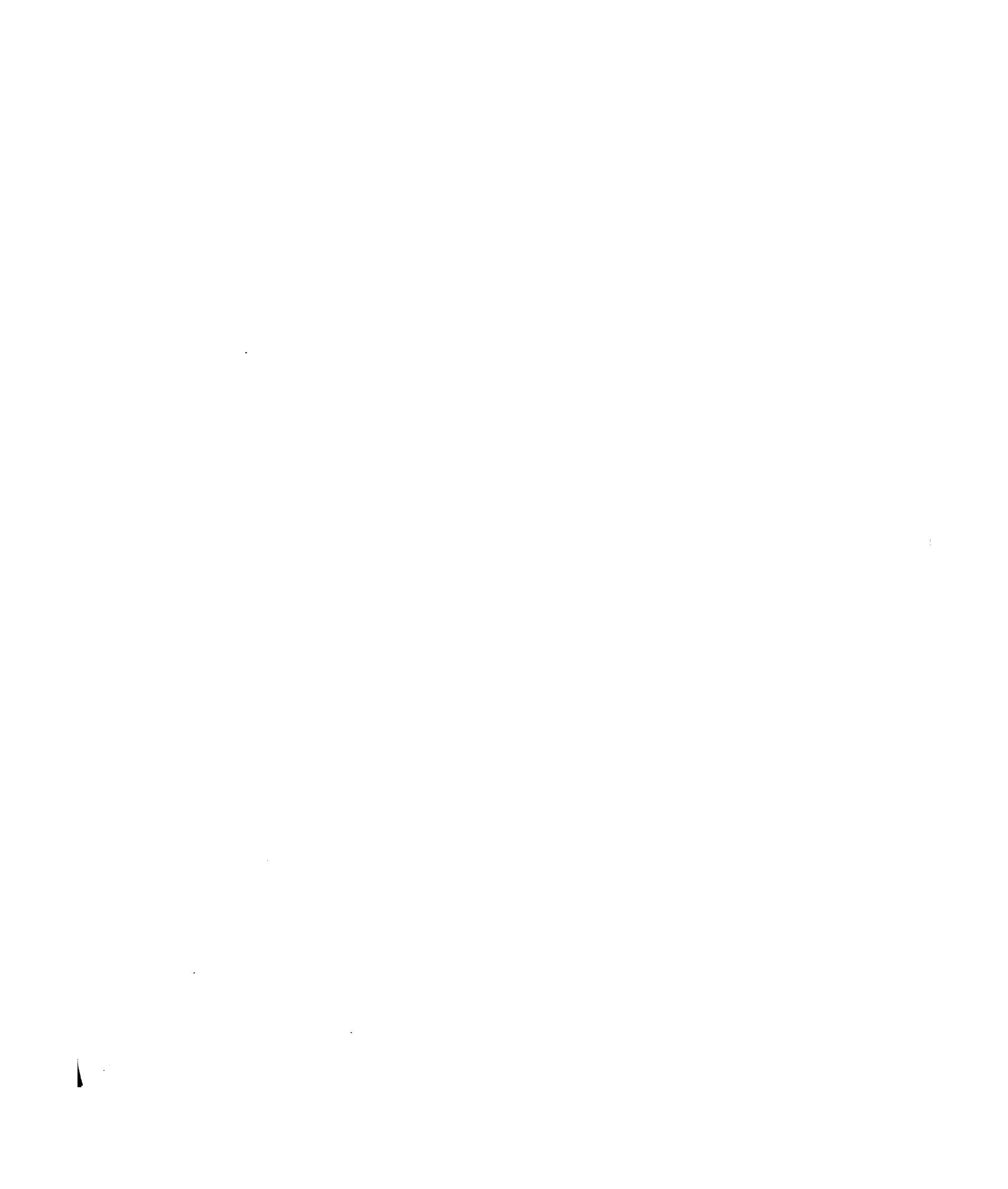




FIG. 36. Two photographs of the same piece of a Great Horned Owl's wing, super-imposed on a photograph of white pine woods, to show how closely the owl's patterns reproduce such a forest-interior.

It is to be remembered that aside from the nesting ordeal, the Ruffed Grouse's greatest need of protection is in the autumn and winter, when many of the trees are leafless. Deep wood interiors are more or less brown, even in summer, and, above the ground, in winter likewise, so that a grouse's colors are never really out of harmony with its environment; but it is in the two brown, leafless seasons between green summer and white winter that the average likeness between bird and landscape is the closest. During the snowy winter months the Ruffed Grouse becomes more largely arboreal, climbing about among the smaller branches of deciduous trees, with almost the agility of a parrot or crossbill, picking buds—which are its principal food at this season. Forest vistas *above* the ground, with the intricately striate pattern of small, naked twigs, are therefore among its commonest winter backgrounds, and a large element of its pattern fits these scenes to perfection.

Another bird which wears a highly developed forest-vista pattern is the American Great Horned Owl (*Bubo virginianus*). This owl sits nearly erect in deep woods, and its obliterative shading is proportionately slight. Horizontal-branch-barrings are the chief pattern of its underside, while its back and particularly its wing-coverts bear a beautifully suggestive picturing of variously extended vistas through the twigs and tree trunks. (See Fig. 36.) The white breast-mark looks like a sky vista, or some other large, light-colored detail of the woodland scene. It belongs among contour-breaking 'ruptive' markings (see Chapter XIII, pp. 77-78) and among those which 'let in' the sky (chapter XXII, p. 149, etc.).

The great European Eagle Owl (*Bubo maximus*) is almost the counterpart of *B. virginianus* in coloration, but somewhat more boldly and sparsely marked, in accordance with its less strictly sylvan life.

The Great Gray or Lapp Owl (*Scotiaptex cinereum* and *S. cinereum lapponicum*), an inhabitant of dense fir and spruce forests in the far north of both continents, wears a congested but little diversified pattern strongly suggestive of the dusky recesses of these northern woods. Most beautiful of all is the forest-picturing on the little Screech Owl (*Megascops asio*) of North America.

As is well known, there are two perfectly distinct color-phases of this owl, the red and the gray. It is in the gray plumage that the forest-pictures are most highly developed. Largely confined to this phase, also, is the curious defensive habit of sitting sharply erect, raising the ear tufts straight upward, closing the eyes to narrow diagonal slits, and drawing the feathers so close to the body that the usually fluffy bird is reduced to about one third its ordinary thickness. Of this interesting performance only one explanation, and one which long seemed sufficient, has been forthcoming. People have supposed that the owl practices protective mimicry, by assuming the aspect of a stick or stub. While it is not to be doubted that such a purpose is often served, in part, at least, yet the fact that the bird has counter shading—which even in the nearly erect position tends to ‘obliterate’ it, and to make it look *unlike* a stick—together with the very evident forest-vista character of its pattern, goes far toward proving that mimicry is not the only object of the trick. The grotesque contraction serves also to bring the *background-pictures to their clearest and sharpest*. The more tightly and closely a bird’s feathers are laid against its body, the clearer do all its markings become. The Ruffed Grouse has a like habit—so have bitterns and many other obliteratively colored birds—and in all these cases the action, whatever may be its other merits, is an essential adjunct of the oblitative equipment. Since, by every token, these birds are preëminently equipped for *obliteration* rather than for mimetic resemblance, it seems likely that the contracting-trick has greatest value as a factor of obliteration. On the other hand, it is undeniable that any such ‘contracted’ bird has moments of close mimetic likeness to a stick or stub. I shall return to this question in a later chapter.

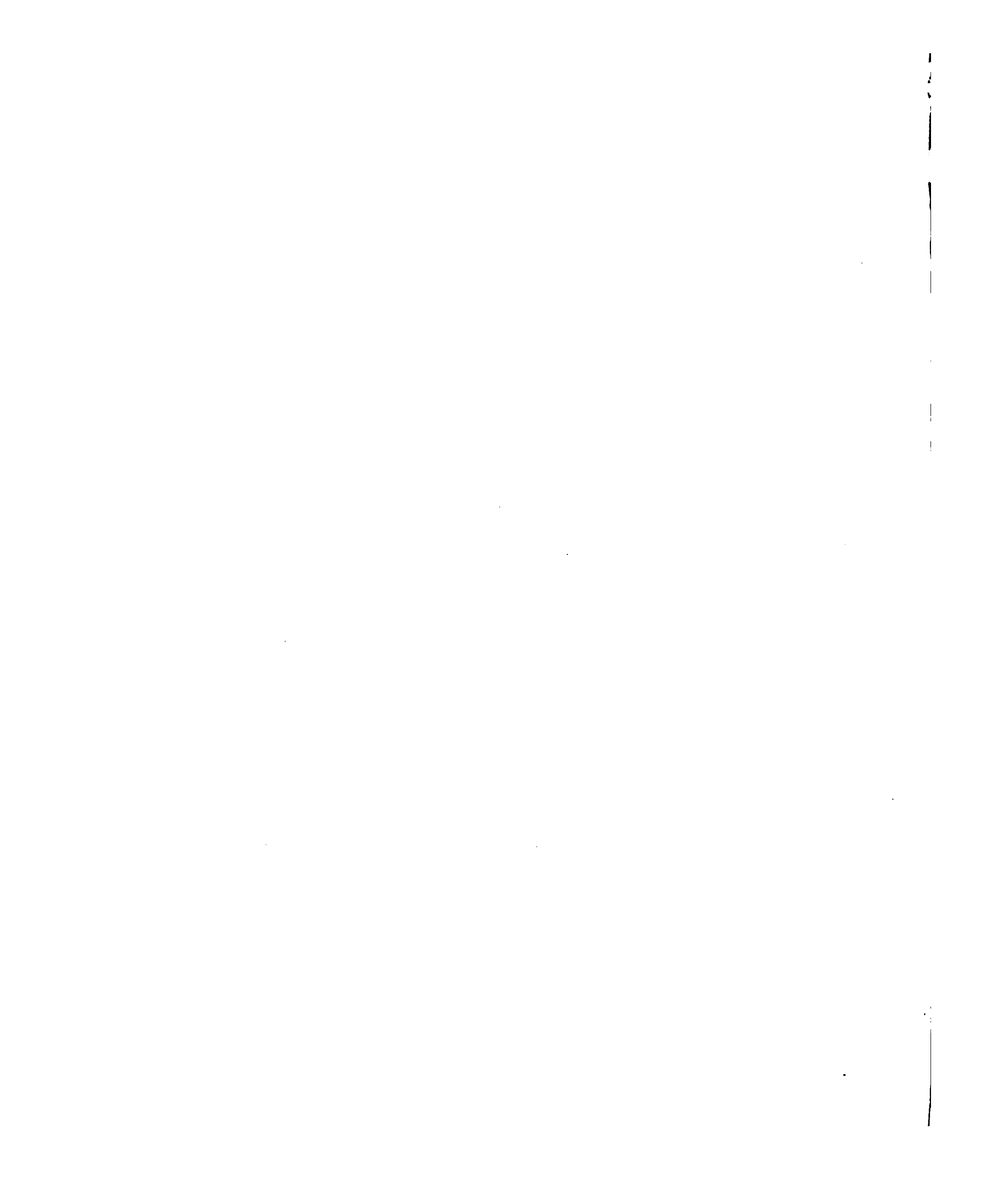
Judged by its markings, the European Woodcock (*Scolopax rusticola*) would seem to belong most decidedly to the ‘forest-vista-picturing’ class, and such an opinion is largely vindicated by an examination of the bird’s habits. It lives to a great extent in upland forest coverts, where its beautiful and intricate wing- and side-pattern matches the vistas among trees and stumps, with glimpses of mottled forest ground, while its barred breast matches



FIG. 37. Stuffed Long-eared Owl in white pine woods. [Cf. the next figure.]
Photograph.



FIG. 38. Stuffed Long-eared Owl in mixed woods. Tree-twig-and vista-picture-
ing pattern (based, of course, on counter-shading.)
Photograph.



standing twigs and branches, and their shadows cast upon the ground. Many other beautiful examples could be given of this type of forest-pattern among birds.

The next chapter will treat of *grass* patterns, separated from the other forms of near-background pattern which have already been considered because of their involving slightly different principles.

CHAPTER VII

BACKGROUND-PICTURING ON COUNTER-SHADED BIRDS, CONTINUED. GRASS AND HEATHER PATTERNS ON SPARROWS AND GALLINACEOUS BIRDS, ETC.

THE grass-pattern birds, of various orders, constitute a pretty clearly defined group in the obliteratively-patterned series. Generally speaking, there is much less diversity in the backgrounds of terrestrial birds which live in the open, than in those of forest birds, whether terrestrial or arboreal. The ingredients of a field bird's background are comparatively few and simple, for the predominant vegetable forms of the open land are much less diverse in size, and somewhat less in shape, than those of the forest. Furthermore, birds that are habitual dwellers on open ground—which, relatively to the littered forest floor, lacks minor variations of level—are rarely seen against anything but a very near background. Thus the possibility of their needing the distance-picturing type of oblitative pattern (as described at the beginning of Chapter VI) is largely eliminated. This comparative simplicity of marking requirements would lead us to expect great uniformity in the patterns of field birds; and investigation vindicates the supposition. Among the birds which are wholly confined to open ground, either bare or grass-grown, but which annually range over a wide territory, so that no one region's peculiar ground-forms could advantageously be pictured on them, there exists a highly conventionalized ground-pattern of a fixed type, which is remarkably little varied through several genera and families, even orders. This type, always based on complete oblitative shading, is characterized by striations of light brown and black, coarsest on the back, and more or less varied by transverse bands and finer markings on the wings, scapular feathers, and other portions. Birds which wear it are Larks (*Alaudidæ*)



FIG. 39. Rocky Mountain White-tailed Ptarmigan in transitional plumage, against snow-brindled ground.
Photographed from life by Edward R. Warren.

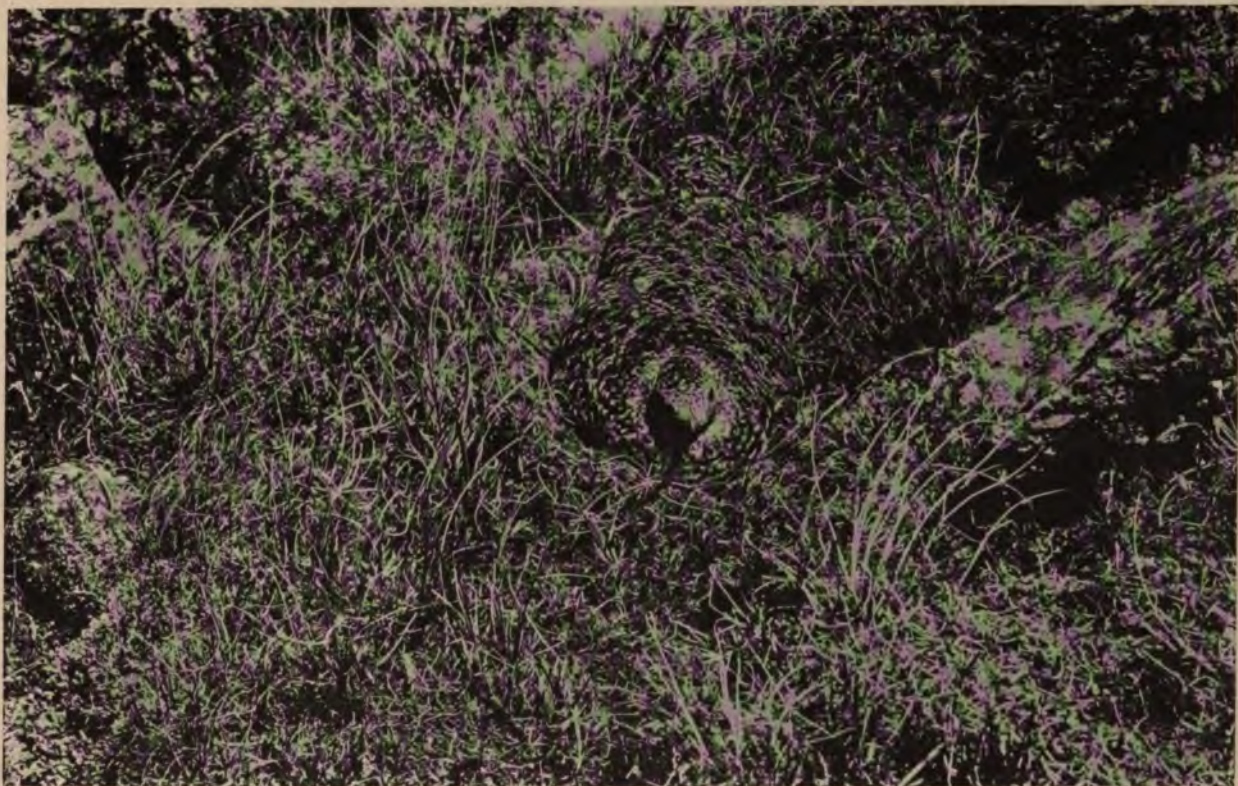


FIG. 40. Rocky Mountain White-tailed Ptarmigan on her nest. Near-ground-picturing pattern, of the grass-type 'based, of course, on full obliterative shading.) [See p. 47, Chap. VII.]
Photographed from life by Evan Lewis.



FIG. 41. Rocky Mountain White-tailed Ptarmigan on her nest. This picture shows the most nearly perfect 'obliteration' of the series, and is a very remarkable photograph. Photographed from life by Evan Lewis. By courtesy of "Bird Lore."

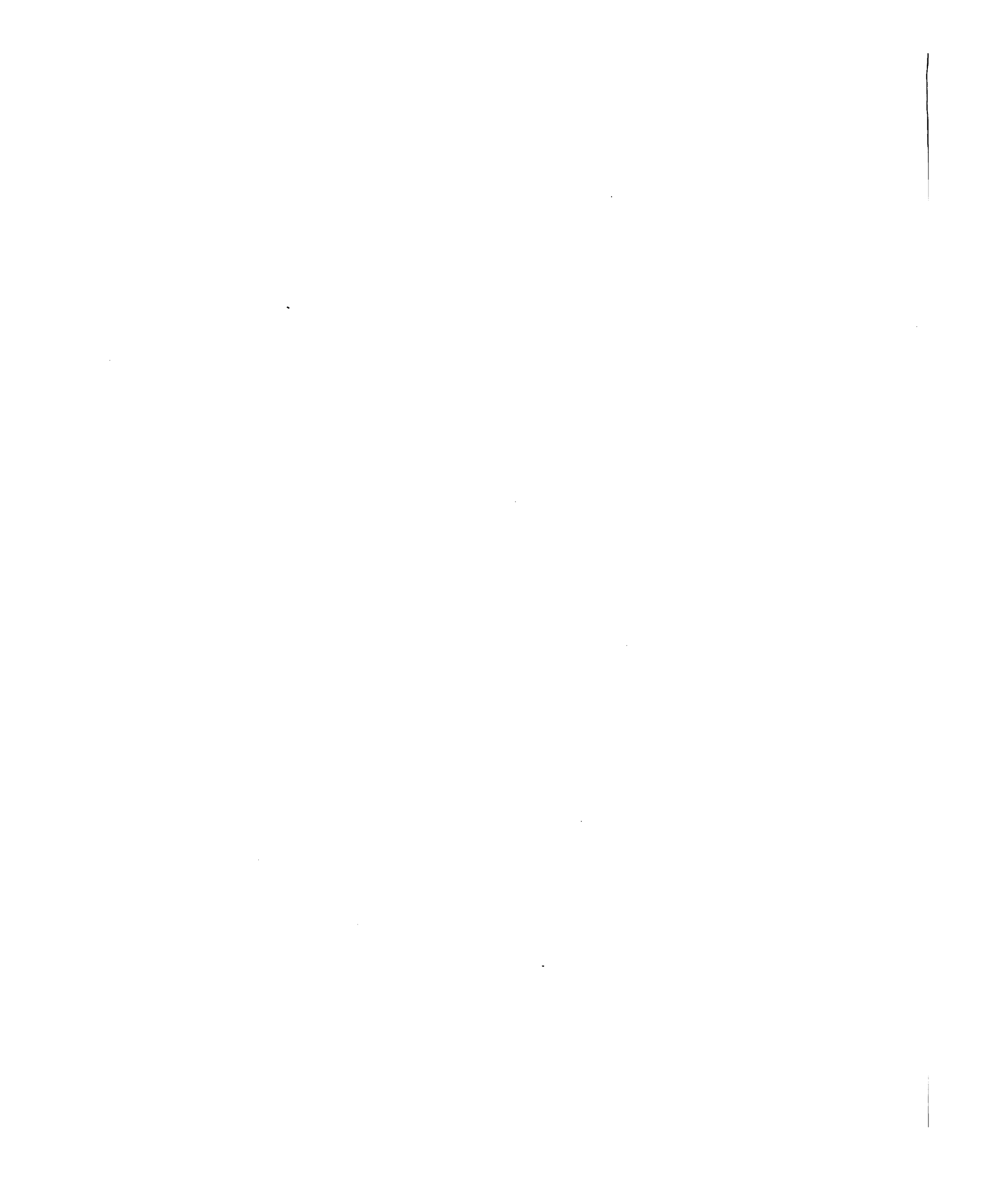




FIG. 42. Rocky Mountain White-tailed Ptarmigan among pebbles, rocks and grasses. (Female and chick.) [Cf. Figs. 39-41.]
Photographed from life by Edward R. Warren.



FIG. 43. Sage Grouse (*Centrocerus urophasianus*), a 'grass-patterned' and 'shadow-marked' bird.
Photographed from life by Edward R. Warren.

(almost all the species except the Shore Lark and its races), Pipits (*Anthus*), certain European Warblers (*Sylvia*), various members of the *Fringillidae*, and some of the shore and moorland haunting *Limicolæ*, as the Curlews (*Numenius*), and other Waders. Some of the more sedentary and local of the migratory field birds, as for example, the North American Yellow-winged Sparrow (*Ammodramus savannarum passerinus*) and the European Quail (*Coturnix communis*), have developed more highly specialized patterns of a very subtle nature,—patterns beautifully suggestive of the intricate small forms of earth and grasses. But it is among the actually sedentary (i. e., non-migratory) ground-birds of mountain moors and pastures, monotonous and little-varied regions, where the forms of vegetable growth which cover the summer ground are very limited in number, that the most simply specialized of background-pictures may be found. Such birds are the Ptarmigans (*Lagopus*), already mentioned as preëminent among special-pattern birds. Living always in exposed situations, and being much sought by many rapacious birds and mammals, they are peculiarly dependent on protective coloration, at all seasons. Almost all the species (the sole exception, as far as I know, is the Scotch "Grouse," *Lagopus scoticus*) turn white in winter, when their boreal or alpine haunts are covered deep in snow. In spring and fall the birds pass through a long intermediate stage, when they are curiously and ever-varyingly pied with white and brown or gray. The fact that they are thereby aided to escape detection on brown vernal ground mottled with patches of melting snow, or on ground half dimmed with scanty autumnal snowfalls, might be considered nothing more than a coincidence, were it not for the extraordinary slowness of the two seasonal color-changes. There is perhaps no other bird which moults as gradually as the Ptarmigan, and this fact goes very far to strengthen the supposition that it has developed a peculiarly fluid and perfect system of perennial protective coloration. Figs. 8, 9, 10 and 39 show White-tailed Ptarmigans, of the Rocky Mountains, in winter and transitional plumages. The photographs were taken from wild birds in their native haunts. Supremely beautiful and potent is the grass-

pattern of this same species in summer plumage. See Figs. 40 and 41, the second of which is one of the most remarkable photographs ever taken of obliteratively colored birds in nature. Both photographs are of hen birds on their nests. We have never been in the haunts of this ptarmigan, and therefore cannot speak from personal experience as to the prevalence on its breeding grounds of the strong, wiry grasses which form the brooding bird's background in these pictures, as well as in others not published here. But the late Mr. Evan Lewis, of Idaho Springs, Col., who took the photographs, wrote us confirming our foregone conclusions as to the abundance and general distribution of grasses of this type in the summer home of the Southern White-tailed Ptarmigan. Indeed, an examination of the photographs leaves one no room for doubt upon this score. So consummate a resemblance could not be merely casual.

The principal feature of the pattern made by grasses over ground is a more or less intricate lace-work of crisscrossing, light-colored, linear forms, some straight, some curled and twisted, relieving with varying intensity against dark. This pattern has the important attribute of simplicity, and is worn not only by many birds and some frogs, but even by certain moths, which rest on the ground during the daytime.* In the case of the ptarmigan, it is achieved by light-brown marginal bands, with a few small internal spots, on the dark feathers of the upper parts; the predominance of light and dark being gradually reversed as the lower breast is approached. The belly is entirely white, as are the quill feathers of the wings and tail. The white of both wings and tail, however, is entirely hidden by grass-marked 'coverts' when the bird is brooding. In addition to the phases already described, this bird has an early autumn plumage of softer and grayer colors, without white blotches, which doubtless fits it to live more among the rocks, and less among the grasses. The colors of ptarmigans, in fact, are almost interminably various, from month to month. It seems almost as if they underwent a *perpetual* moult. The grass-pattern plumage of the nesting season, however, must be very constant.

* These will be considered later.



FIG. 44. Scottish Grouse (*Pharmigan*) on her nest, showing the 'heather-pattern'; 'The bird, however, was badly lighted for 'advertising.' Photographed from nature by G. Bond, Woburn. Reproduced by courtesy of 'Country Life,' London.

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FIG. 45. Nesting Scotch (Trous) Ptarmigan.
Photographed from life by Cherry and Richard Keston.

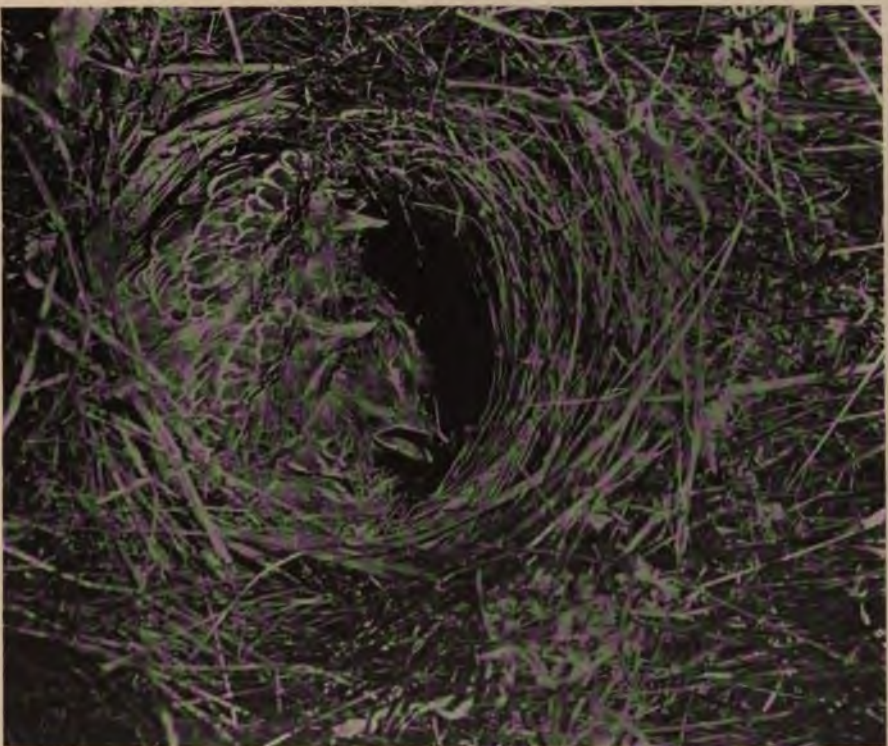


FIG. 46. Young Western Meadowlark in their ground nest. 'Grass-pattern' birds.
Photographed from life by Pinoy & Hobman.

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FIG. 47. Nesting female Eider Duck. Ground-picturing pattern, based on counter-shading.
Photographed from nature. By courtesy of "Country Life," London.



FIG. 48. Young Short-eared Owls, in their nest on the ground.
Photographed from life by Cherry and Richard Kearton.

Another kind of Ptarmigan of which we have secured good photographs from life is the *Lagopus scoticus*, the so-called "Grouse" of the British Islands (Figs. 44 and 45). This is preëminently a bird of the heather, and it is gratifying to see how subtly and significantly its markings differ from those of the American species which nest among grasses. It is completely covered with wonderful heather-pictures, recognizable as such even when the bird is examined away from its true environment. The more complex forms of the crowded and delicately branching heather plants, with their twigs and leaves and blossoms, are copied by various modifications of the bird's pattern. Relatively to that of the grass-ptarmigans this pattern is characterized by the multiplicity of its small, light-colored forms, which are also greatly more varied both in shade and color, to simulate the complexer surface-pattern and interior-vistas of the heather plants, with their variously illuminated details. (Technically, the difference consists chiefly in the wider and wavier marginal bands, and in a copious speckling of darker brown upon the fuscous ground-color within these bands.) The bird shown in Fig. 40 was unfavorably arranged as to obliterative shading, but certain features of its obliterative *pattern* are shown off to consummate advantage. The pattern of its rump and back is scarcely recognizably different from that of the heather around its tail and nearer wing, while the picturing of heather-bells by its breast-pattern is astonishingly close. The obliterative shading of this species is so extremely slight that we must infer that it is wont to lie very deeply settled into the heath, and often more or less overarched by it, so that the preponderance of direct top-light is reduced to a minimum. The dark area on the actual belly, which this species shares with several other gallinaceous birds of different genera, has little or no bearing on the case, as it is invariably out of sight when the bird is "lying close." (The use of such markings will be discussed in a later chapter.) The ptarmigans which resort often to bare ground and rock, as also the *arboreal* Gallinæ, lack this 'squatting-patch,' and light bellies are essential factors of their concealment. Even some of the rock-haunting ptarmigans, however, have a somewhat weak obliterative shading, and this is

in keeping with the fact that on mountains there is an unusually great proportion of *side-light*.

Still another notable type of pattern worn by birds of grass-lands and the open plains, is composed of a system of bold transverse bars of black and brown, or kindred colors. This exists, for instance, on some of the Tinamous (*Tinamidae*) of South America, and, in a very high state of development, on the European Great Bustard (*Otis tarda*). Its effect is much the same as that of the other grass-patterns, but it seems in most cases to be a cruder and less highly finished form. The pattern of the Little Bustard (*Otis tetrax*) is somewhat of this type, though refined toward elaborate picturing, and is very beautiful and effective. The female especially is one of the most exquisitely counter-shaded and picture-patterned of birds.



FIG. 49. Yellow Wagtail amid grasses.
Photographed from life by Cherry and Richard Kearton.

FIG. 50. Male Bob-white (*Colinus virginianus*) on its nest. Highly-developed picture-pattern, based on full obliterative shading.
Photographed from life by Mansell S. Crosby. Courtesy of "Bird Lore."



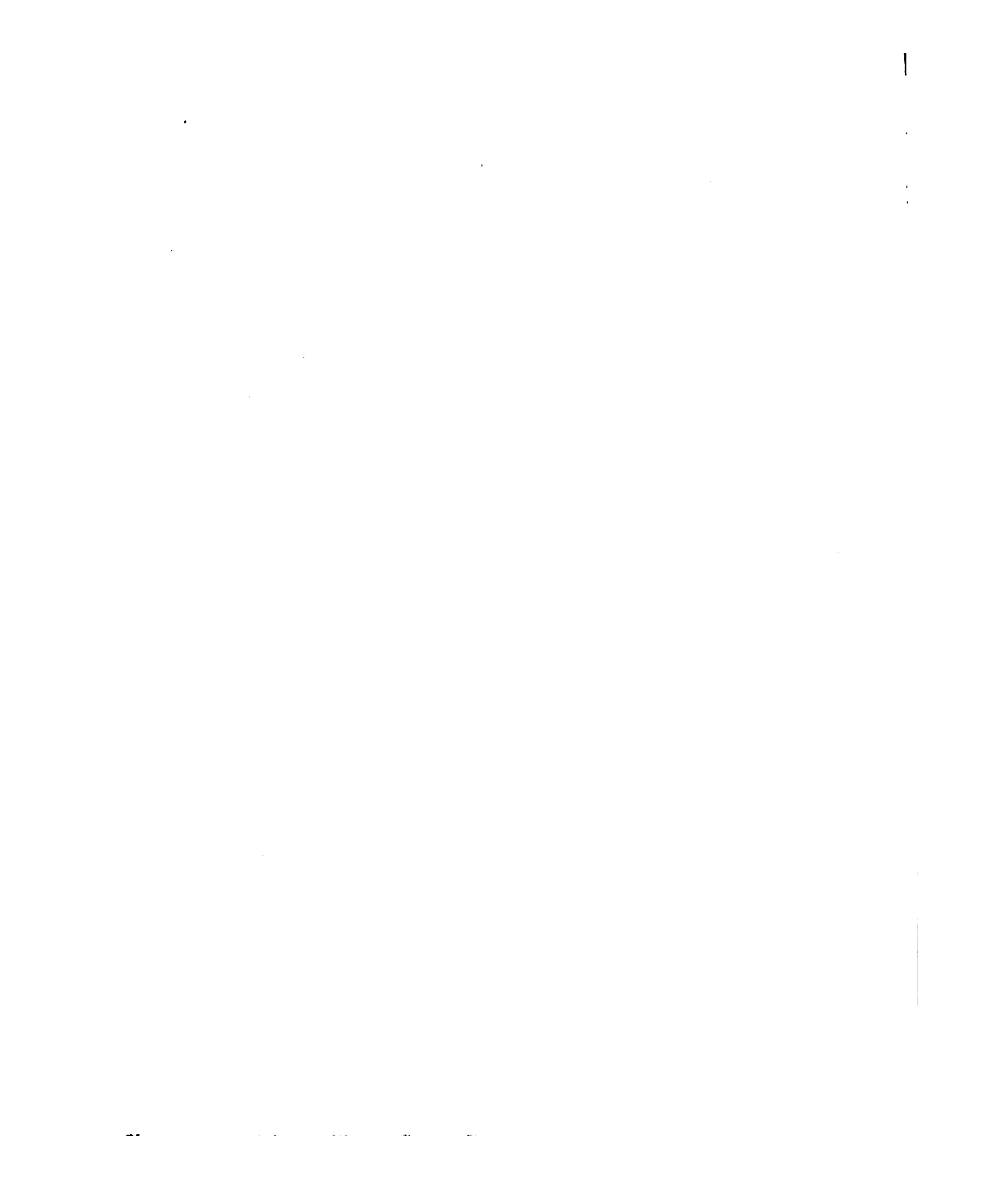
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FIG. 51. Male Golden Plover with chick, in grass. Obliterative shading and grass-picturing-pattern, etc. This bird is also a heather-haunter. [See p. 53, Chap. IX.]
Photographed from life by Cherry and Richard Kearton.



FIG. 52. Nesting "Upland Plover" (Bartram's Sandpiper), a 'grass-pattern' bird.
Photographed from life by J. E. Seebold.



CHAPTER VIII

BACKGROUND-PICTURING ON OBLITERATIVELY-SHADED BIRDS, CONTINUED. THE VARIOUS PATTERNS OF SCANSORIAL BIRDS

SCANSORIAL birds are for the most part tree-trunk climbers. They are the Woodpeckers (*Picidæ*), the Wrynecks (*Jyngridæ*), the Nuthatches (*Sittinæ*), the small Northern Creepers (*Certhiidæ*), the Wood Creepers (*Dendrocolaptidæ*), and a few other forms.

Most of these birds—notably both families of Creepers—spend almost all their time in a nearly vertical position, clinging to the bark of tree trunks with claws and tail, or claws alone. The Nuthatches climb head-first downward as well as upward, the others seldom or never do.

In spite of the erect climbing-position in which they spend their lives, these birds are almost without exception dark on the back and light on the breast and belly, and many of them have a delicate, complete gradation from the dark side to the light. The underside may be pure white, as in the case of many woodpeckers, or brown, barely lighter than that of the back, as in some of the *Dendrocolaptidæ*. But in the whole catalogue of species we know of none which is not thus counter-shaded, more or less pronouncedly. But how, then, the reader may ask, does this regulation counter shading conform with these birds' *vertical* habit of life? The answer is plain. The solid, leaf-crowned trunks up which they climb cut off the light from their breasts, and almost all that reaches them strikes laterally or diagonally on their backs. It is the same scheme over again, but carried out on a vertical instead of a horizontal plane.

The patterns of these climbing birds are extremely various, ranging from none at all, as in some of the Wood Creepers, etc., to exquisitely elaborate

bark- and vista-pictures much like those worn by goatsuckers, as in the Wry-necks.

The unmarked Wood Creepers—whose counter shading also, in some cases, is very slight—frequent brown stumps and trunks, in very heavily shaded forests. Other members of the same family, with closely similar habits, have streaks and a more pronounced counter shading.

Bark picturing plays a very large part in the disguises of several classes of animals, probably reaching its consummation among moths and butterflies, as we shall see later on. Cruder * forms of it among birds are represented by the streakings and mottlings of the Creepers (*Certhiidae* and *Dendrocolap-tidae*), by the close transverse barrings of the backs of certain Woodpeckers, and the bold spottings and stripings of other members of that family. All these devices, especially the barrings and stripings, are, at a little distance, effective bark-pictures. The pattern of the small Northern Creepers (*Cer-thia*) is perhaps too highly developed to be rightly classed among these others, and should be treated rather as a connecting link between them and the exquisite picture-pattern of the Common Wryneck (*Jynx torquilla*). This last is one of the most wonderfully equipped and beautiful among obliteratively-colored birds, and is evidently one which, like the goatsuckers, often stays stock-still in time of danger, allowing its enemy to make an exceedingly near approach before it moves. Its buff-colored breast and rufous primaries bear the same form of transverse dusky barring as is worn by so many of the larger forest birds, while its back is mottled and lined and peppered with several tones of gray and dusky, in minute picturing of bark seen at close range. In back view the bird would usually be seen against the very tree to which it is clinging, in side view usually against branches and trunks, and more distant forest vistas. And behold! its markings are developed correspondingly.

* Whenever we call a coloration cruder, or less developed, without trying to state the function of this so-called crudeness, it must be understood that such a function surely exists. It is, evidently, only the need of this coloration to represent different backgrounds, that can limit its development toward any particular one.—A. H. T.

On its sides (breast, cheeks, flanks, wing-coverts, etc.) are the delicate twig-and vista-pictures, and on its back the near-bark marblings. The beautifully banded tail serves well in either view. Indeed, the Wryneck's oblitative coloration involves the same principles and sorts of background picturing as does that of the Ruffed Grouse and other forest birds described in Chapter VI.

We have now glanced at most of the main types of coloration among tree-trunk-climbing birds. In a later chapter I shall recur briefly to the subject of the bolder markings of woodpeckers and nuthatches.

CHAPTER IX

BACKGROUND-PICTURING ON OBLITERATIVELY-SHADED BIRDS, CONTINUED. BEACH-SAND- AND PEBBLE-PATTERNS OF THE SHORE BIRDS (*Limicolæ*). GENERALIZATIONS AND COMPARISONS

OBLITERATIVE shading, pure and simple, is the rule among the Shore Birds (*Limicolæ*). There are a few somewhat anomalous cases—e. g., the summer costumes of the Golden and Black-bellied Plovers, and the Dusky Redshank (*Totanus fuliginosus*), which we will consider later on; but for the most part the birds of this order show great simplicity and uniformity in their oblitative coloration. The markings of many of the species which inhabit pebbly shores and wave-marked, sandy beaches are much like those of the grass-pattern birds described in Chapter VII, but even simpler.

Littoral flats, whether of sand or shingle, are for the most part characterized by great monotony and blankness, being governed by few and simple laws, and almost wholly wanting the complex element of vegetable life, with which we have had mainly to deal in the foregoing chapters. Since the birds that inhabit these beaches are almost all great wanderers, making long semi-annual migrations, one would expect to find their patterns not only simple but highly generalized, and varying little among the species. A comparison of the more strictly littoral among the smaller shore birds will show that this is actually the case. There are, indeed, two quite distinct types among them, but almost all the species belong to one or the other of these two. The one includes those which are largely destitute of picture-pattern—e. g., the smaller plovers (*Ægialitis*), the other those which are well provided with such patterns, of a regular and simple kind—e. g., many of the sandpipers (*Tringa*, etc.). The patterns of sand and shingle and tidal mud flat are apt to be so slight that a bird can be well concealed on such ground by counter shading

and color alone, as in the case of the plovers; but Nature has given many of her beach-birds a picturing of the faint patterns. Wave-lines left at low tide on bright sandy beaches, narrowed in perspective, the lines of small lapping rollers over shallows, strips of stranded driftweed, shells, heaped or scattered, straggling blades of beach grass—these, varied by the even speckling of broad pebble-beds, are the chief features of the ground-scene on blank shores where sandpipers and plovers troop and feed. So do we find the bird's pattern, wherever it occurs, delicate and linear and wavy, with few intricacies, and a persistent tendency toward lengthwise striping and crescentic spots. The effect may be produced by light markings on dark, by dark on light, or by both; but the patterns are all much alike in general character. *Marginal bands* play the chief part in all these simpler picture-patterns, and this is even truer of the *beach* than of the *grass* type. These two phases of pattern are well connected by intermediate forms, worn by some of the *Limicola* that live more or less largely in the fields or moorlands. Such are the Curlews (*Numenius*), already mentioned among grass-pattern birds, the Thick-knees (*Edicnemidæ*), and the North American Bartram's Sandpiper (*Bartramia longicauda*), which has, indeed, one of the most highly specialized of 'grass-patterns.' (See Fig. 52 and Chapter VII.)

Again, among the true plovers we find an outcropping of the *heather* pattern, in conformity with the heath- and tundra-haunting habits of the birds that wear it. Such are the several races of the Golden Plover (*Charadrius*), which breeds in the far north of both continents, and, to some extent, its relative the Black-bellied Plover (*Squatarola*), of like distribution.

Good examples of the pure beach type are the winter costumes of the Knot (*Tringa canutus*), the Sanderling (*Calidris arenaria*), the Semipalmated Sandpiper (*Ereunetes*), and the Stints (*Tringa minuta*, *T. temminckii*, etc.). Most of the birds of this family wear a more grass-like pattern in summer than in winter, a fact which is in perfect keeping with their habits, for during the nesting season they tend to forsake the beaches and to live among the weeds and grasses. Some, like the Pectoral Sandpiper (*Tringa*

maculata), stick to grassy swamps throughout the year, and their pattern tells the tale.

The true snipes (*Gallinago*), already treated of in another division because of the rich intricacy of their markings, have a pronounced element of grass-pattern, and both in markings and in habits form a connecting link between the grass birds and the woodland bog birds, typified by the American Woodcock (*Philohela minor*). In like manner the sand- and pebble-type of pattern is modified toward rock-surface picturing,—as in the winter plumage of the Purple Sandpiper (*Tringa maritima*), one of the most highly ‘obliterated’ of birds, and a sandpiper peculiar in its restriction (at least in winter) to *rock-bound* ocean shores. In the same way the pattern of the terrestrial goat-suckers, described in Chapter V, is modified toward rock-picturing in the plumage of that rock-haunting member of the family, the Nighthawk (*Chordeiles*).

From all this it appears that the types and forms of picture-pattern worn by birds, though easily separable into classes when grouped about the several conspicuously pure examples, are yet in the whole range of species closely blended and intermingled, more or less irrespective of the structural affinities of the birds which wear them, but nearly always in obvious conformity with their specific habits. It would seem, indeed, as if Nature in its entirety should represent one great, blended scale, shaded throughout insensibly like the colors in the spectrum, and as if the breaks and interruptions which form the bases of zoölogical classification and separate grouping were in a sense imperfections. In the world of birds, for instance, though the breaks and anomalies are numerous, there are yet many evidences of the past existence of a smooth gradation connecting types now sundered.* On the other hand, it is also true that gaps in the fundamental affinities of birds are often superficially bridged over by similar habits, probably of more recent acquirement, and these are usually accompanied by corresponding outward resemblances,

* See Robert Ridgeway, in the preface to his “Birds of North America,” whence much of this thought is taken.

particularly those of plumage. Thus we discover, even in the study of the disguising-coloration of the birds of to-day, a wonderful intermingling and gradation between the types, which makes it hard to consider them separately. But division and classification are essential to analysis, and by taking a prominent type-center as the theme of a chapter, we can better examine both its differences and its affinities. Those we have already glanced at are perhaps the most representative and notable of the many types of picture-pattern worn by obliteratively-shaded land and beach birds. It remains for us to consider the markings of rails and other swamp birds, of obliteratively-shaded ducks, etc., and also the several oblitative uses more or less independent of counter shading which are served by spots and patterns in birds' costumes.

CHAPTER X

BACKGROUND-PICTURING ON OBLITERATIVELY SHADED BIRDS, CONTINUED. REED PATTERNS AND OTHER MARKINGS OF BITTERNS. THE COLORATION OF HERONS IN GENERAL

ONE more pronounced modification of the 'dead-grass' type of picture-pattern must be considered. This is the picturing in a near view of straight, erect reeds, which exists on the necks and heads of several herons, notably the American Bittern (*Botaurus lentiginosus*), which shall serve as our example. Many herons are wont to stand motionless, with neck and head extended and erect, and in the bitterns this habit reaches its climax. The American Bittern will stand for an hour at a time in a swampy meadow, with scarcely a movement of its erected, straight and stick-like neck and head, terminating in the long, sharp bill, which points directly upward. When, as is pretty frequently the case, the neck and head in this position project above the reeds or grasses, they look, in certain lights, and from a sufficient distance, like a pointed stick or stub. This fact has been commented on by many writers, all of whom, it seems, have thought it a sufficient explanation of the Bittern's curious trick. Though we admit that the stick-aspect is sometimes most pronounced, and must therefore have a bearing on the significance of the habit, we are convinced that this has another function of far greater importance, namely, the display in correct position, and with the clearness gained by depressed feathers, of the reed-stripes on the upper neck, which extend sharp and unbroken over the head, and are even continued on the bill. The following extract from my journal, recording my first recognition of the high obliterative efficacy of these stripes, contains some details which make it worth quoting: "But if this [stick-mimicry] were the explanation, what would be the function of the finely developed, sharply contrasted stripes

of light and dark, running lengthwise of the head and neck, and best shown when the bird is standing erect in the attitude alluded to, with feathers closely depressed? It is plain that these markings cannot help the 'stick' aspect, but must rather injure it, inasmuch as a single stick or stem would be of uniform coloration, or at most mottled, rather than marked with sharp and strong longitudinal stripes. The true explanation flashed into my mind to-day as I was watching a standing Bittern at a distance of about ten feet. The light stripes on the bill were repeated and continued by the light stripes on the sides of the head and neck, and together they imitated very closely the look of separate, bright reed-stems; while the *dark* stripes pictured reeds in shadow, or the shadowed interstices between the stems. The truth of this explanation must be apparent to any one with an eye for such things, who watches at close range a Bittern standing motionless among reeds." To be sure, Bitterns' heads and necks are often seen projecting stick-like over the tops of meadow-grasses and half-grown reeds, but who knows how many times Bitterns' heads in this same attitude *among* the reeds escape all notice, by virtue of their beautiful rush-pattern? It may very well be that the projecting-stick aspect is, relatively at least, exceptional and unimportant. My own observations of Bitterns in their haunts all tend toward such a conclusion.

Reed-like patterns occur also, though in less marked development, on the necks of some of the true herons, as for instance the Purple Heron (*Ardea purpurea*) of southern Europe. The beautiful European Bittern (*Botaurus stellaris*) has kindred markings with a strong admixture of richly brindled grass-pattern—a pattern at once bold and subtile, whose oblitative effect in the bird's normal environment must be consummate. So also with the South American *Botaurus pinnatus*. The Least Bitterns (*Ardetta*), of Europe and America, have also delicately reed-marked heads and necks. There are doubtless many other examples which might be cited, but these are all that occur to me.

A modification of the type of grass-pattern described at the end of Chapter VII occurs on the South American Tiger Herons (*Tigrisoma*), with their

minute transverse barrings or grizzlings of olive and black. Like the bitterns, they are inhabitants of reed and grass swamps. All these birds have obliteratively-shaded bodies, and—in the slight degree consistent with the characteristic nearly erect position of these parts—obliteratively-shaded necks and heads.

The coloration of herons in general is exceptionally various, including as it does such extremes as the richly mottled brown of bitterns and the immaculate snow-white of egrets and some others,—the supposed “conspicuous” species. (In a later chapter we shall show that these egrets too, and all such birds, are obliteratively colored.) Herons walk and rest, very commonly, almost erect, and their oblitative shading is often not very pronounced, though present, and evenly developed, in the majority of species. The colors of shallow and shaded water—subdued blues and greens and purples, sometimes enriched and subtilized by iridescence,* predominate in their plumage, and they usually have bright reed- and water-colors on their naked legs and bills.† Their markings are various, sometimes pronounced and clear, sometimes obscure, or even lacking altogether, but almost always perfectly and obviously consistent with the water-picturing suggested by their general color-tones. It is significant, too, that in spite of the much diversity in herons’ colors, there are no brown and elaborately-patterned species except some of those that live in grassy marshes and dense reed-swamps, where they skulk almost like rails—the first subjects of our next chapter.

* See p. 92, Chapter XVI.

† See Chapter XV.



FIG. 53. American Bittern on its nest, 'obliterated' by picture-pattern based on counter-shading. (The 'reed-stripes' mentioned in the text are here not in full operation.)
 Photographed from life by E. G. Tabor.



FIG. 54. Nesting Virginia Rail, 'obliterated' by counter-shading and background-picturing pattern.
 Photographed from life by E. G. Tabor.



FIG. 55. Wilson's Tern on its nest. (Counter-shading and) 'ruptive' pattern.
 Photographed from life by Francis H. Herrick. Courtesy also of G. P. Putnam's Sons.



MALE WOOD PECKER ON SHALLOW WATER

Painted by J. J. Audubon

MALE WOOD PECKER IN A FOREST

Painted by J. J. Audubon

The bird was painted from a stuffed specimen and the background copied, color-note from the bird's own. Of the background of the landscape figure 23; the bird-of-paradise, plate 11; and the landscape.

EXPLANATION OF PLATE III

MALE WOOD DUCK ON SHALLOW WATER.

Sketch by Richard S. Meryman

MALE WOOD DUCK IN A FOREST POOL.

Painted by Abbott H. Thayer, assisted by Richard S. Meryman

The bird was painted from a stuffed specimen, and the background copied, color-note for color-note, from the bird himself. Cf. the backgrounds of the Rattlesnake, Figure 123; the Bird-of-Paradise, Plate VI; and the Flamingoes.

CHAPTER XI

BACKGROUND-PICTURING ON OBLITERATIVELY SHADED BIRDS, CONTINUED. WATER MARKINGS AND COLORS

THE duskiness of oblitative shading on such birds as rails, gallinules and coots, is in keeping with their habit of skulking under deep marshy cover, closely shaded from the direct top light, and often, momentarily, lighted more from the side than from above. A true oblitative shading exists, however, on almost all the species. Two or three main types of coloration prevail among them, but there is little variation beyond these types, and only such as is consistent with 'obliteration.' The colors of water, much like those worn by herons, predominate among the more aquatic species, the coots and gallinules. Olive, green, blue, purple, slate-gray, dusky—these are characteristic gallinule colors, and likewise the colors of water. A few of the birds that wear them are scantily or not at all counter-shaded. The Purple Gallinule (*Ionornis martinica*) for instance, with its bright but softly-blended water tones, is as dark beneath as above, though there is a counter shading from the middle of its back to the lower edge of its folded wing. It lives for the most part over deeply and diversely shaded pools, and amidst the big, glistening leaves of water plants, and its peculiar coloration does certainly achieve adequate 'obliteration.' (This will be explained more fully in a later chapter.) It is noteworthy, however, that in almost all cases where the adult plumage of one of these swamp-haunting species lacks oblitative shading, that of the young possesses it in full. This is true not only of the Purple Gallinule, but in a remarkable degree of some of the jacanas, as the common *Jacana jacana* of South America. These birds live in tame and noisy flocks

on shallow lakes, lagoons, and miry marshes, and, unlike rails and gallinules, they do not skulk and stick to cover, but stay almost always in the open reaches, where they are exposed to the view of predatory birds and beasts. The adults are black underneath and rich red-brown above, with pea-green wings. As birds go, they are apt to be conspicuous, although not always easily discernible amidst the multitudinous sharp lights and shadows of the labyrinths of lily pads over which they often walk. Watching a flock of jacanas feeding under the noonday sun, one sees from a little distance mainly the black-breasted adults—of the more daintily-colored, white-breasted young there seem to be only two or three in the whole flock of a score or more. But when the horizontal sun-rays of late afternoon or early morning stream across the marsh, behold a revelation! The young, concealed till now by their counter shading, show up in quantities, outnumbering the adults almost two to one. This is a most beautiful and convincing exhibition of the power of obliterative shading, and one which must leave a lasting impression on the mind of every observant person who sees it. But it suggests also an interesting question—so interesting that, though it leads us into the tabooed region of hypothesis, we must be permitted to discuss it briefly. Why are the adult jacanas deprived of the counter shading which served their youth so well? Adult gallinules also, it is true, lack counter shading, but they are always alert to skip into deep cover at a moment's notice, whereas the jacanas, as I have said, live in flocks, conspicuously exposed, in the open tracts of lagoons and marshes, and rarely or never take to cover unless wounded. Is it not highly probable that the strong spurs on their wings have something to do with all this? May it not be that the young, weak-spurred and inexperienced, need concealment in situations where the adults, with their hard, sharp thorns, are well able to protect themselves?* Undoubtedly, the dark-hued parents must often serve to distract the attention of predatory creatures from their obliteratively-colored but defenseless young. Certain it is that these spurs are not, like those of cocks

* There must, of course, be situations where the adults are as obliteratively colored as the young.—
A. H. T.

and pheasants, for battles among the birds themselves, for they are worn equally by the *small males* and the *much larger females*. Evidently, then, they are for defense against outside enemies, such as alligators, iguanas, tortoises, and predatory birds and mammals. That they are very effective weapons seems to be attested by the birds' abundance, noisiness, and tame and nonchalant manner.

The colors of rails differ from those of gallinules and coots (and differ even among the several species), exactly as do their habits. They are more terrestrial, and their general color-scheme accordingly is browner. The backs of many species bear a subdued and dusky striate pattern of the 'grass' type—richer and brighter on the more terrestrial kinds, and *vice versa*. (See Fig. 52.) Some are slate-gray underneath, others pale rufous, or grayish white; but almost all have a complete counter shading, with a light culmination on the vent and belly. Some, like the Yellow Rail (*Porzana noveboracensis*), have a background-picturing pattern of delicate, grasslike, pale-brown barrings. But it is the patterns for which the birds of this family are peculiar that we have here to consider. These are the characteristic barrings on the flank feathers (in *Rallus*) and the system of pure-white specklings and slender stripings on the dark-colored upper sides (in *Porzana*)—markings which, although not, indeed, strictly limited to the rails, yet reach an unusually high degree of development and significance among them. *Water* pictures of some kind they plainly are; and it is not difficult to go further and perceive what details and aspects of reed-swamp surfaces they most resemble. The white punctations picture broken glints of sky-shine on the dusky water, seen beyond and through the dim vegetation-pattern, rendered by the darker markings of the birds' backs. The barred flank-pattern pictures glimmering water intersected by bold shadows from the reeds—or by intervening shaded reeds themselves. That crane-like relative of the rails, the Courlan (*Aramus*), the ground-color of whose costume is the deep, dull brown of heavily shaded, muddy water, has likewise a water-glint pattern of pure-white spots on its head and neck. This I have seen performing admirably its 'obliter-

ative' function, on a wounded bird in hiding. The white specklings of some of the Wood Sandpipers (*Totanus*) and various other water-haunting birds (e. g., the loons, *Gavia*) belong more or less strictly to this same class of 'water-glint' pictures.

So, too, the rails' barred flank-pattern has affinities with the markings of other water birds, such as certain ducks. On them, however, it is developed into ripple-picturing. The beautifully contrasted black-and-white bars on the flanks of the Wood Duck (*Aix sponsa*) are *ripple pictures*, and as potent, in their place, as the most elaborate markings of land birds—while they are even more remarkable in that they depict *motion*. These markings of the Wood Duck cross the flank feathers transversely, yet when the feathers are laid in their natural *upcurled* position, overlapping the wing, their pattern forms one brilliantly accentuated *horizontal* stripe. Thus, though made by flank feathers, this marking is merely another form of the longitudinally striate scapular- or wing-pattern worn by so many other ducks, and serves exactly the same purpose. More than two thirds of the American and European ducks have one form or another of this marking, and on many of them it is most pronounced. It corresponds to the 'secant' stripe of certain land birds, but is often more elaborate (consisting sometimes of several tiers of stripes), and has an even more definite 'obliterative' use. It may be seen in its perfection on the Wood Duck, already mentioned, on the Pintail (*Dafila acuta*), the Green-winged Teals (*Nettion*), the Garganey (*Querquedula circia*), the Widgeons (*Mareca*), the Golden-eyes (*Clangula clangula*, etc.), the Long-tailed Duck or Old Squaw (*Harelda hyemalis*), the Steller's Eider (*Eniconetta stelleri*), the Hooded Merganser (*Lophodytes cucullatus*), and the Red-breasted Merganser (*Merganser serrator*). Its position varies from the flank feathers, as in *Aix*, to the secondary wing feathers, as in *Merganser*, the tertiaries, as in *Mareca*, and the scapulars, the feathers of the sides of the back, as in *Dafila*, *Nettion*, *Harelda*—in fact, the great majority of species. Its character and effect, however, are nearly the same in these several positions. A swimming duck leaves a spreading, wedge-shaped trail of curling ripples, very noticeable

in quiet water, while shorter ripple-lines also roll out in front of the bird's breast. Seen in profile against the water, the duck's body hides a portion of the perturbed and wavy surface extending from its further side, and tends to 'relieve' noticeably against it. But this 'relieving' Nature combats with the bright 'secant' stripes, which, by their beautiful likeness to rolling wavelets, with shine and shadow, go far toward 'merging' the duck's otherwise well 'obliterated' body into the troubled water beyond it. The peculiar ripples, real and pictured, may still suggest a swimming bird, but just where the bird really is—where alone the eye is led to expect it—there seems to be nothing but water,—for the wave-lines extend across its dim body. This is a very important factor of disguise among ducks, particularly those that inhabit quiet inland water. Among deep-sea ducks it is less common. But the same system, sometimes elaborated, and including sharp transverse markings, occurs on a few of the oceanic species.

Another peculiar form of pattern, common to even more kinds of duck, is a fine, black or gray vermiculation of the back or sides, as on Teals, Scaups, Canvasbacks, Wood Ducks, and many others. Indeed, this pattern is almost universal among ducks, and there are comparatively few (these mostly deep-sea kinds) that lack all trace of it. It serves as a generalized picturing of shimmering water, fretted with broken shore-reflections, or ruffled into tiny ripples by light breezes. Considering its prevalence among highly 'obliterated' water birds, one can hardly doubt that such is its main function. On some species which frequent shallow inland waters, like the Wood Duck and the Hooded Merganser, the dusky vermiculation is exceedingly close and delicate, over a ground-color of golden brown. In these cases it seems to picture the sandy bottom seen through shallow water at the stream's or pond's edge. As a rule, the vermiculated pattern occurs on the *sides*, and its minuteness therefore fits it to match its wearer's more or less distant watery background, with its ripples and reflections dwarfed and refined by perspective. The much coarser wavy markings of some geese, though they serve also the purpose of ground- and grass-picturing, in conformity

with the birds' half-terrestrial habits, have yet much in common with ducks' grizzled water-patterns; and the two types are connected by intermediate forms, e. g., the breast-pattern of the Ruddy Duck (*Erismatura jamaicensis*).

Ducks have still another very characteristic oblitative marking, the bright-colored "speculum"—a broad band, often of metallic green, blue, and purple, crossing the middles of the secondary wing feathers. This marking can but poorly serve the purpose (commonly supposed to be the main function of all such marks) of *display in flight*, for the color is confined to the tops of the outer webs of the wing feathers, and so only makes a continuous band when the wing is *folded*. Its *oblitative* use, on the other hand, is most pronounced. It gives the effect of a '*window through the body of the bird to the water or vegetation beyond*.*† This speculum is almost always of some characteristic water tint—blue, green, or gray. Often it is highly iridescent, which makes it additionally effective (as will be explained at length in a later chapter). On some species, such as the Scaups (*Aythya marila*, etc.), it is white. But even pure white serves the same 'oblitative' purpose, picturing a sky-reflection on the background-water.

All these factors in the disguising costumes of ducks are usually parts of an 'oblitative' scheme based on full oblitative shading. Very few ducks lack this counter shading, and most of them have it in full development, particularly the females, and the males in post-nuptial summer plumage. The singular change to a dull-colored summer dress, like that of the females, which most male ducks yearly undergo, is coincident with their loss, and lack, for many weeks, of all flight-feathers. Discussing this phenomenon, an eminent English ornithologist remarks:‡ "Most of these birds (*Anatidæ*)

* Much the same purpose is served by the beautiful metallic spots or patches of water-color (deep blue, green, and violet) on other parts of the body, worn by many sea ducks, notably Steller's Eider. This bird has indeed a supremely beautiful pattern of ice and water pictures.

† Little used while the duck is swimming, but greatly when he walks about on the adjacent shore, in far greater danger from his enemies. These speculums prove, also, to have a wonderful power to obliterate their wearers against the sky, to the eyes of creeping enemies that flush them.—A. H. T.

‡ See the "Encyclopedia Britannica," vol. iii, p. 776 (of the R. S. Peale Reprint).

shed their quill-feathers all at once, and become absolutely incapable of flight for a season, during which they generally seek the shelter of thick aquatic herbage, and it is further to be particularly remarked that the males of two sections of the family (*Anatinae* and *Fuligulinae*) at the same time lose the brilliantly-colored plumage which commonly distinguishes them, and 'go into eclipse,' as Waterton happily said, putting on for several weeks a dingy garb much resembling that of the other sex, to resume their gay attire only when, their new quills being grown, it can be safely flaunted in the open air." Here are the facts, but without the true conclusion which should be drawn from them—the conclusion which is unavoidable in the light of a wider knowledge of protective coloration. This is, that the male duck's assumption of dull plumage is an adaptation to his *new environment*, rather than to his *altered bodily condition*. He skulks among the reeds because he is flightless, and he assumes a mottled grass- and reed-like pattern to fit him to this new environment; but the mottled pattern is no more protective, i. e., 'obliterative,' than the pied *water*-pattern of his full plumage, worn when he forsakes the shelter of the shore. Male Eiders (*Somateria*) keep out at sea while their brown, mottled females (see Fig. 47) hatch the eggs (sometimes a long way from the water) and tend the young, and though the males (as well as the females) are flightless for a while, they retain their full plumage almost unaltered. This full plumage has no oblitative shade-gradation, but consists of a bold 'ruptive' pattern of ice- and water-colors—as will be further explained in a later chapter. A few male sea-ducks, such as the more or less wholly black Scoters (*Oidemia*), are conspicuous at sea, though well equipped for inconspicuousness against dark cliffs. Their females, which have to brood the eggs on shore, are more or less adequately 'obliterated' by counter shading, color, and markings. There are, however, some species of swimming birds in which even the females are quite without counter shading. Such are swans,* for instance, and cormorants—though cormorants are otherwise equipped for concealment on shore by rock-like

* See p. 154, Chapter XXII.

markings, and by iridescence, which must often admirably mask them under water also.

The foregoing sketch of ducks' disguising coloration touches on most of the main general facts. But the reader must now be subjected to a detailed description of the oblitative equipment of one particular species, the Wood Duck, the male of which is almost unsurpassed among birds in the combined boldness and intense subtlety of its disguising coloration. (See Plates III and IV.) The general scheme of this beautiful bird's 'disguisement' includes a full and potent oblitative shading, from blue-black on the back and tail to pure white on the entire underside, shading through sand-color on the flanks and through chestnut, mixed with white, on the breast. The throat also is white, ending abruptly against deep velvet bronze and purple on the cheeks. Founded on this underlying oblitative shading, which cancels the bird's visible solidity, and prepares him for 'background matching,' there is a bright and beautiful system of water-pictures, of many kinds, bolder and more vivid than those of any other bird we know (with the possible exception of Steller's Eider). For the most part, these pictures are of shore- and sky-reflections, subtly and richly intermingled, and comprising a great variety of effects. The colors are mainly deep and soft, though rich, and liquidly alive with sober iridescence. Their range (excluding the sandy flanks) is from chestnut red glossed over with purple, through all degrees of blue to golden green;—perfect woodland water colors, all of them. Olive-ash color occurs on the lesser wing-coverts and primary quills, and this, the tint of lusterless still water near the shore, between reflections, is a connecting link between the brighter water-pictures and the sand-colored sides. The scapulars, which meet over the back, are somber blackish, with a glimmering of blue; water deeply shaded, showing a dark bottom, or reflecting something dusky. The "speculum" and some of the greater wing-coverts, together forming a patch which intervenes between the back and flanks, and, longitudinally, between the two areas of ashy olive, are bright and lustrous blue, ranging from almost purple to deep robin's-egg, and including also, on a single

feather of the speculum, a blended patch of copper red, sometimes combined with greenish bronze and purple. All these feathers are iridescent, but their changeableness is mainly from dusky to bright, rather than from one bright tint to another. They render beautifully a portion of the surface of the dim translucent water where there is a somewhat vague reflection of the sky or of plants above. Forward, this patch is blended softly into the ashen olive of the wing-coverts; while the speculum is bordered outwardly with a band of white—like a sharp streak of the clearest sky-reflection on the elsewhere dim, semi-transparent water. So, in lesser degree, with the grayish-white longitudinal stripe formed by the outer veins of the folded primaries, above sharply bordered with dark blue (the outer veins and a narrow stripe next the shaft on the inner veins of the primaries), and forward blended smoothly into the ashen-olive patch at the bases of the primaries. This combination of softly blended with clean-cut, sharp-edged markings is what gives the water-picturing its peculiar magic, for it represents the two main characteristic elements in the aspect of quiet water, namely, vistas *through* the surface into the liquid depths, and *reflections, on the surface*, of things above. As in the duck's costume, so in the water which it pictures, these two elements are now sharply differentiated, and now intimately blended.

Most potent of all, perhaps, are the pictures of *reflection* on the Wood Duck's richly crested, green and purple head, with its clean-cut stripes and bars of snowy white. These white marks picture bright and sharp reflections of the sky (their sharpness of outline caused perhaps by straggling wavelets which 'cut' and border them) lying on the dark, translucent water, tinted by vague reflections from the shore. Or, again, the white and dark marks, all together, suggest a definite, fixed reflection-picture of a fringe of bushes along the shore, with the bright sky beyond cutting in among their crowns, and showing here and there between them, lower down. The white on the head and neck and cheeks shows duly bright, while that on the throat, from which the higher spots are offshoots, is, in the bird's normal life-postures, dull with shadow, and belongs mainly to the obliterative shading. In the resultant

water-picture it renders a duller sky reflection, mixed perhaps with under-water effect.

The deep chestnut breast is blended above into dusky olive, on the fore-back and neck, while below it fades away into the immaculate white belly, the transition being effected by a series of triangular white flecks, extending downward in crescendo progression from the upper breast. (See, in connection with this and other points in my description, Plates III and IV.) This rich and lustrous chestnut, fleckless in its anterior and upper third, and glossed with purple and weak green, is an admirable picture of translucent, shaded water near the shore, either reflecting faintly the muddy bank and brown-stemmed bushes, or dimly revealing its own dusky, earth-colored bottom. Bounding the back edge of this chestnut, and separating it from the wing and side, is a bold 'secant' band of black and white (like that worn by certain teals, but stronger), vertically extended, but slightly crescentic, and pointing forward. Sharply 'secant'—seeming fairly to cut the bird in halves—this marking is also intermediate in character between the reflection-picturing patterns of the head and the ripple-pictures on the flanks. For it depicts with almost equal fidelity at least two types of detail—a narrow sky vista reflected side by side with a dark stem or tree trunk, and a sky reflection glancing from the side of a sharp, single ripple. At least two evident purposes are likewise served by the beautifully graduated white triangles on the chestnut breast, downward growing larger and larger until they completely veil the brown and blend it into the white of the belly. First, they are agents in the oblitative shading, and second, they admirably picture small glints of bright reflection on the faintly tremulous surface of quiet, shaded water. In this function they are the same as the punctate shine-pictures on the backs of rails, wood sandpipers, loons, etc., mentioned earlier in this chapter.

Chestnut like that of the breast, but more strongly glossed with purple, forms a broad patch on either side of the Wood Duck's rump, back of the ripple-picturing flank feathers. It is unflecked, and blends into the dusky and velvety-blue-green tail, just as the breast's chestnut blends into the olive

back. Downward, this rump-mark blends into dusky-olive under-tail-coverts. Tail and rump together picture a patch of dark water, with blended, weak reflections, relieved by a streak or two of reflected shore-color in clearer definition. These streaks, which are shining rufous brown, are formed by the central barbs of two or three of the loose-webbed, lengthened upper-tail-coverts; they relieve against dusky green.

The ripple-, sand-, and water-shimmer pictures on the Wood Duck's flanks have been described in an earlier part of this chapter, but to complete this elaborate account we must revert to them, describing them in greater detail. The whole extent of the sides and flanks, from the crescent breastmark to the chestnut patches on the sides of the rump, is occupied by a uniform pattern of minute black vermiculations or undulatory lines, closely crowded over a ground-color of light brownish yellow. Below, this patch fades into the white of the belly; above, from a point barely in front of its middle backward, it is bordered by the remarkably bold and vivid ripple-pictures already mentioned, formed by broad, alternate bands of snow and jet. These bands are on the tips of the longest of the grizzled feathers, and, as has been told, they cross them transversely, yet by the curling upward of these feathers the bands are made to form oblique or even horizontal streaks. Rising out of and surmounting the grizzled brown—which pictures either tremulous, opaque water, or, more vividly, a submerged bed of sand—these richly contrasted black and white streaks and crescents look wonderfully like a crowded company of fresh-made, hurrying ripples; just such, in fact, as the swimming bird himself produces. Thus the ripple-marks he leaves in his wake and those that roll out from his further side are continued and repeated on his obliteratively-colored body, and this gives the final touch of perfection to his 'vanishment.' In the marvelous completeness of this 'vanishment,' this 'invisibility' in full and near view on quiet water, he is possibly unique among swimming birds. One may scan a Wood-Duck-haunted pool for many minutes, at close range, and fail to see the ducks that are floating on it; just as one often looks in vain for the Ruffed Grouse that is perching motionless in the apple tree. Like

the grouse, like the summer ptarmigan and the woodcock, the duck is, as it were, 'dissolved' into its vari-patterned background, by perfect oblitative shading and picture-pattern.

Two details of the male Wood Duck's costume have yet to be mentioned, his gaudily-painted bill and his marbled under-wing-coverts. The bill is marked with bright yellow, red, white, and black, and in connection with the varied water-scene rendered by the bird's plumage, it must often pass for a reflection-picture of bright-colored things like flowers, on the shore—or perhaps for the actual blossoms of water plants. But it is to be supposed that the flowerlike aspect of the bill renders its owner a still more direct and simple service, by separately disguising that implement of offense from the insects and other small but active creatures which form a part of his diet. A pied, flowerlike bill would probably, in the long run, succeed better in the capture of its agile prey than would a dull and normally tinted one, without deceptive color or markings. Of this the reader is to hear more in a later chapter.

The use of the black-and-white marbling of the under-wing-coverts and axillars, shared by both sexes, is not surely apparent. But it seems likely that both the color and the markings of these feathers serve chiefly or wholly for 'obliteration,' coming into play when the birds are sitting and walking about in trees (a habit highly characteristic of the species), with wings frequently half spread. The ground color of white then becomes effective in neutralizing the shadow, as in the case of the belly, and the dusky specks and bars constitute a generalized oblitative pattern tending to 'merge' the wing, visually, into its freckled forest background. This pattern is in fact closely akin to that of many out-and-out forest birds.

The female Wood Duck is colored much more dimly than her mate. Her wings alone are almost exactly the same, and fully as bright; otherwise, her predominant color, aside from the white of her belly, is ashen olive, lustrous with green and purple on the back, scapulars, and crown, verging toward brown on the sides and toward ash-gray on the cheeks, and reaching lustrous olive-green on the upper sides of the tail feathers. Her flanks show no traces

MALE WOOD DUCKS.

Upper one: Sketch by Abnett H. Thayer.
Lower one: Painting by Richard S. Meryman

These paintings show one of the very common situations in which the boldest contrasts of a male Wood Duck's coloring come into play in preventing his showing his silhouette.

His dark areas, with all their varied colors, here 'become a part' of the like-colored dark reflections in the water, and his white patterns exactly reproduce the bright sky-reflections, so that he is so to speak 'dissolved' into the scene.--A. H. T.



of the sand and ripple pictures which are such important details in the vesture of her mate, being marked instead with blurred, broad streaks of pale yellowish gray, on a ground of olive-brown. On the whole, her costume lacks pronounced water-pictures, seeming to fit her rather for life in secluded recesses among reeds and bushes, and for perching among gray tree trunks, which she has frequently to do in the nesting season. When brooding, although most commonly quite hidden in a hollow tree trunk, branch, or stump, she is at times more or less exposed to outward view; and this fact also must have a bearing on the significance of her coloration. When she is sitting in the hollow end of a large broken branch, perhaps even with some of her foreparts projecting beyond its rim, her oblitative coloration must often be most potent. (Audubon has figured a female Wood Duck in such a situation, and mentions it as not uncommon.) But aside from their probable connection with her ordeal of brooding, and guarding her ducklings among the reeds and bushes, her soft markings and colors and perfect counter shading make her at all times a thoroughly 'obliterated' bird—even though she lacks the bright and elaborate water-pictures of the drake. . Both drake and duck are among the world's most subtly beautiful birds, and their oblitative coloration demands especial study.

The Mandarin Duck (*Aix galericulata*) of the Orient, nearly akin to the Wood Duck in all respects, has an equally beautiful and still more remarkable costume, but one which is less unmixedly of the water-picturing type. In the drake's dress there are a few important peculiarities which call for careful study of him in his home; but the female does not differ essentially from the female Wood Duck.

CHAPTER XII

BIRDS OF THE OCEAN

PURE white prevails in the costumes of the long-winged birds that habitually range the open sea, and their patterns are further characterized by an almost total lack of small markings. In coloration as in environment, they are the antithesis of the sedentary and seclusive land birds which live mainly on grassy ground or in the mottled realms of woodland—such as the ptarmigans, grouse, goatsuckers, etc., described in earlier chapters. The Shore Birds (Chapter X) are a connecting link between the two extremes. As their average environment is much more plain and simple than that of the grouse or ptarmigan, so are their oblitative patterns much less richly and elaborately wrought. The step is short from these birds of the barren borderland between earth and sea, to the long-winged rangers of the blank and hoary sea itself. Here are no sharp and fixed small forms at all, but only the eternal counterplay of two vast and simple fluent elements, atmosphere and water. True, even in open ocean there are characteristic patterns made by the moving waves and ripples, and these are reproduced on some of the marine animals, notably certain surface-swimming fishes. (See Chapter XXIV.) But the coloration of the long-winged, wide-ranging sea birds copies the prevalent *blankness* of sea and sky and cloud. Though often resting on the surface of the water, they are of course less intimately bound down to it than the ducks, auks, murre, etc., being in fact eminently aerial rather than natatorial; and this is in accordance with their wanting the wave and ripple pictures worn by many ducks and murre. Chief among these long-winged sea birds for delicate beauty of 'oceanic' coloration are the *Laridæ*, or gulls and terns.

Nearly white all over though most of them are, in the adult plumage, they are yet obliteratively shaded, having "mantles" of darker or lighter bluish gray on the back and wings—and in the case of many terns, crown-caps of black—while all the remainder of their costume, with the exception of a few more or less dark-marked quill feathers, is, in most cases, fleckless white. Black markings aside (these we shall discuss later), this obliteratively disposed combination of soft, water- and cloud-like pearly gray with bright, shadow-absorbing white is just such a coloration as insures its wearers, whether flying or swimming, the *greatest average inconspicuousness* against the ocean. Often they show light against dusky water, but just as often they show dark against water brightly sky-lit; and hence in many intermediate cases they must pass unseen, matching their 'background' as does the ptarmigan or grouse in its appropriate domain, although so much less intricately. All this concerns the aspect of the gulls as seen from *above*, against the *ocean*. But they have little to dread from flying enemies, and the more vital service rendered by their coloration is doubtless *concealment against the sky above, from the eyes of aquatic animals below them*. Like the Snowy Owl, the white herons and egrets, and, in part, the skunks, deer, antelopes, etc., to be described in a later chapter (Chapter XXII), these ocean-rangers are admirably equipped for inconspicuousness, in a great many views, against the sky itself. Thus, even to the eyes of their aquatic enemies and aquatic prey, they wear the universal complete oblitative coloration. Pure white or largely pure white though they are, they must often relieve *darkly* against the sky, as *always* when seen directly overhead. In many views, on the other hand, they 'melt away' into their skyey backgrounds, as do the white, masking rump-marks of many ruminants, and the white back- and head-patterns of many grubbing carnivores (Chapter XXII), etc. As the normal background of these sea birds is the unbroken sky, varied only by unbroken, sky-reflecting ocean, so their prevalent coloration is such as achieves pure and simple sky- and ocean-picturing. On most of the true gulls (*Larinæ*) the white of the rump, tail, and entire underside extends also to the head and neck. The head's consequent lack of counter shading is

evidently more than compensated by the sky-matching power which uniform, pure white gives to this most vital and most dangerous portion of the gull, either when he is resting on the water, with head held erect, or—and perhaps more particularly—when, as he flies or swims, his head is stooped toward, to, or even beneath, the surface, in search of food.

White or largely white-marked heads are common to a good many other birds, not counting the habitual *swimmers*, which get their living from the water; witness the Bald Eagle, the Osprey, the Great Blue Heron, etc. In all these cases they perform the same service of 'obliteration' *against* the sky. Some gulls, on the other hand, such as the Black-head (*Larus ridibundus*), of Europe, and the Laughing Gull (*L. atricilla*), of America, have dusky hoods enveloping the entire head. All or nearly all the kinds thus marked are inhabitants of bays and lakes and marshes rather than the open sea. Furthermore, the dark hood is worn only by the adults in the breeding season, when, amid the blackish mud and dusky shadows of the salt marsh or inland swamp, they well serve as 'ruptive'* masks. So do the jetty crown-caps of nesting terns—except that these belong to oblitative shading as well as to 'ruptive' pattern. (See Fig. 55.) Like the gulls' hoods, they are as a rule features of the breeding season only—in the autumn largely giving place to white, the regulation sky-matching color. But the black markings on the quill feathers both of gulls and terns are worn throughout the year, and probably serve both as 'distractive' marks † when the birds are fishing, and as combined 'distractive' marks and 'picture patterns' when they are brooding on shore amid shadows and other dark landscape-details.

For the most part, however, the coloration of these gulls and terns in adult plumage is suited to the sky and sea rather than to the land, and they are apt to be conspicuous on their breeding grounds, by virtue of their paleness. Their downy young, on the contrary, are almost always well 'obliterated'

* See Chapter XIII, p. 78.

† See Chapter XXII, p. 151.

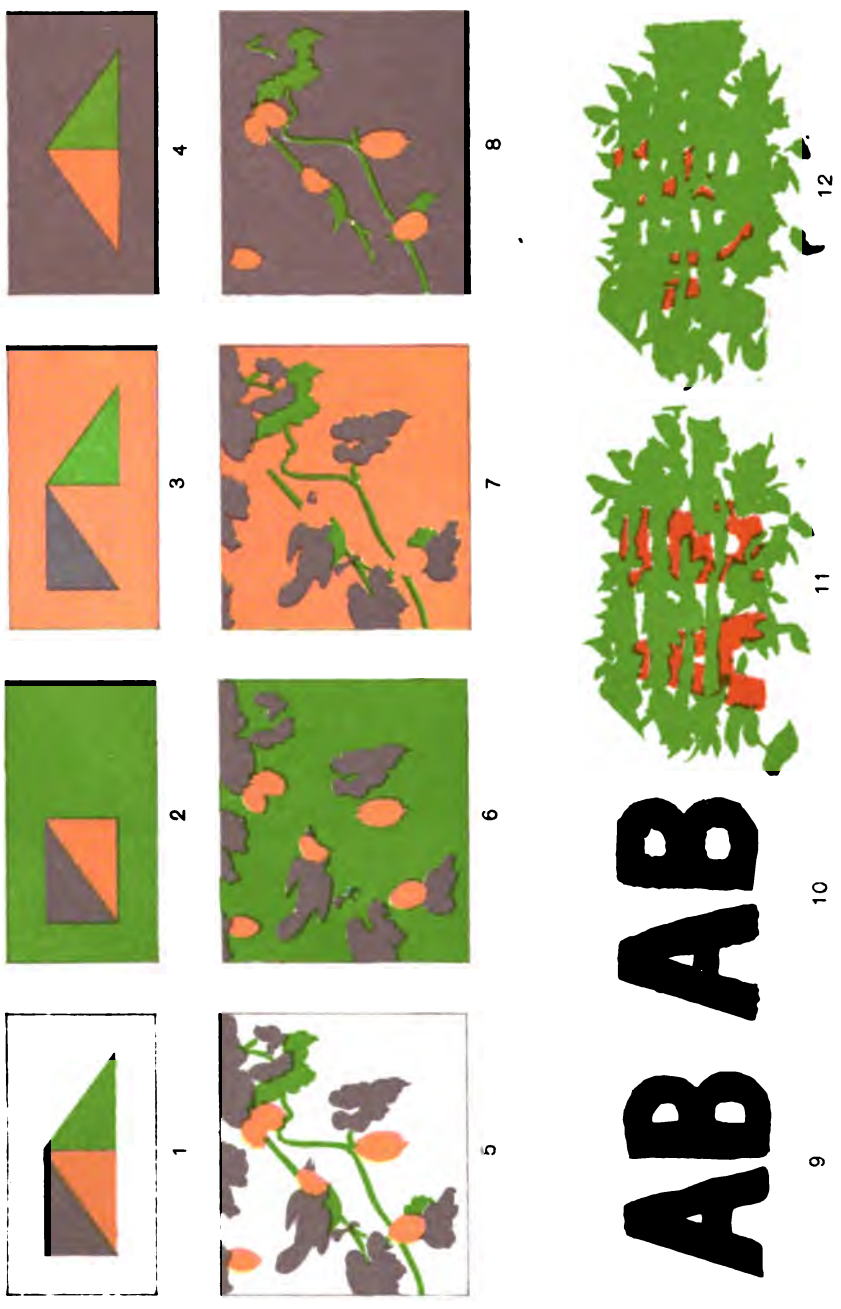
by counter shading, color, and near-ground markings.* (See the young gulls in Fig. 75.) Mottled brown, dusky and gray costumes of various degrees of darkness are worn for two or three years by the young of the larger gulls, and it is a noteworthy fact that during this period they are more addicted to living on and about mud-flats, marshes, and muddy lagoons, than are their white and free-sea-ranging parents.

Among the other groups of long-winged sea birds, there is a good deal of diversity in coloration, but at the same time a persistent tendency toward whiteness and the lack of small markings. Sky-matching costumes, indeed, reach high and simple development among the gannets, tropic birds, albatrosses, fulmars, and others.

The smaller jaegers or robber gulls (*Stercorarinæ*) have in the usual adult plumage full obliterative shading, being fuscous brown or slaty gray above, and white below, sometimes with small markings (dusky flecks) on the breast and sides; and their young wear a heath- and grass-picturing pattern of brown and dusky. But the symmetry of these facts is marred by the existence in at least two of the three or four white-breasted species of a second adult color-phase, in which the costume consists of sooty brown with a comparatively slight counter shading. Here, as in the case of the black leopards and jaguars (see Chapter XXI, p. 133), there may be something to discover in the way of corresponding varietal peculiarities of *habits*. But jaegers are parasitic harriers of other birds, and prodigiously swift of wing, so that, except during the nesting time, they doubtless have comparatively small need of disguising-coloration. Strange as it may seem, however, a good many other aërial sea birds are colored much like the melanistic jaegers—i. e., almost uniformly dark brown or black above and below. Such are several of the *Tubinares*,—shearwaters, petrels, albatrosses. But almost all these birds, in addition to being largely nocturnal, nest in dark earth-burrows or rock-fissures, and this habit has doubtless a significant connection with their queer coloration. Many other species of the same families, as well as various long-winged sea

* See Chapter XIV, pp. 82 and 83.

birds of other orders, are obliteratively shaded, from pure white to dusky brown or gray, with or without connecting middle tones. Though often very inconspicuous against the sea, such dark-backed birds are of course less well equipped for 'vanishment' against either sea or sky than are the beautiful white and pearl-gray gulls and terns. These have, indeed, the very acme of oceanic oblitative coloration.



AB AB

Diagrams from 1 to 8 inclusive show how each of an animal's colors is cut out of his silhouette when he is seen against a background that matches it. On green, the green is lost; on gray, the gray is lost; on orange, the orange is lost; and the remaining silhouette is *not that of the animal*.

Diagrams from 9 to 12 inclusive show the cooperation of interposed vegetation with pattern to conceal animals.

No. 9 shows the letters A. B. executed in orange.

No. 10 shows the same letters colored green and orange.

In Nos. 11 and 12 a green pattern has been superimposed upon Nos. 9 and 10.

The *monochrome* letters continue visible through this tracery, but the orange-and green-patterned ones are entirely obliterated by it, the orange alone remaining distinguishable wherever it is not covered. Green seen through green holes is, of course, inseparable by the eye from the like-colored green leaves that frame it. Even the interposing of a tracery that matched neither note of the letters would conceal them by causing them to show different colors through different interstices. These diagrams show that all patterns whatsoever upon animals amidst vegetation cooperate with the vegetation to conceal them.—A. H. T.

CHAPTER XIII

BIRDS, ETC. THE INHERENT OBLITERATIVE POWER OF MARKINGS. 'RUPTIVE' AND 'SECANT' PATTERNS, ETC.

UP to this point we have considered markings and patterns almost solely as adjuncts and dependents of oblitative shading. As far as ground-haunting species are concerned, this function of markings seems by far the most important, but they have yet a separate and inherent significance, which among non-terrestrial species is often the dominant feature of disguise. As we have seen, perfect uniformity of coloration makes a thing conspicuous, allowing every part to assume exactly the aspect dictated by its own form, without exaggeration or omission. Markings, on the other hand, of whatever sort, tend to *obliterate*,—to cancel, by their separate and conflicting pattern, the visibility of the details and boundaries of form. The main solidity, and its details, are shown by graduated light-and-shade—the outline, the external contours, by relieving either light or dark or differently colored against the background. To all this *markings* are unfriendly, both on objects *actually* monochrome and therefore *visually* not so, and on objects which present, with the aid of counter shading, a perfectly monochrome appearance. Rapid and manifold are the vicissitudes of illumination and relation to background of a moving bird or butterfly among trees and open spaces. Now it is dark against a sky vista, or against brightly-lighted foliage, and the next instant, by some slight change in its position, or in that of the beholder, it shows light against dark shadow-spaces. (See Figs. 56-57.) Delicate picture-patterns cannot avail against these grosser 'visibilities,' but strong 'secant' and 'ruptive' patterns can. If the bird's or butterfly's costume consists of sharply contrasted bold patterns of light and dark, in about equal propor-

tions, its contour will be 'broken up' against both light and dark—light failing to show against light, dark against dark. Such is apparently the basal and predominant use of almost all the bolder patterns in animals' costumes. Often such bolder markings play a part in subtler schemes of picture-pattern; but, on the other hand, they sometimes work independently of obliterative shading. 'Secant' patterns, however, are almost always in its service, even when they have some share of independent effect. A good example is the longitudinal light-colored stripe on the scapulars or wing feathers, so very prevalent among obliteratively colored birds—particularly those with highly developed picture-patterns. It is found in its perfection on certain sparrows and many gallinaceous birds. In almost every case it clearly pictures a horizontal stick or grass-blade, with its shadow under it; but, picture or no picture, it tends to cut the aspect of the bird in two. This marking is found also on certain kinds of wood frog, and on toads. (See Chapter XXIV.) There are also *vertically* 'secant' markings, e. g., the white or black-and-white breast-bands of some teals (*Nettion*), and of the Wood Duck (*Aix*), both mentioned in an earlier chapter. 'Ruptive' markings, in general, are bold, massed patterns of contrasting shades and colors, disposed at seeming haphazard over the animal's body, but in reality arranged according to the rigid laws of disguise. Among birds thus marked, some of the best examples are sea fowl, Eider Ducks, for instance. Male Eiders, with their big, contrasting patches of black and white and buff and green—or grayish blue—are doubtless very inconspicuous in deep ocean water among ice cakes; while their brown, grass-patterned mates are well fitted for the task of brooding their eggs on the dry shore. The non-counter-shaded male Harlequin Duck (*Histrionicus histrionicus*), likewise, is in aspect cut to pieces by its queer, black-rimmed white markings, which look like floating bits of ice, or patches of snow on rocky shores. Many other sea ducks wear kindred markings, and so do many land birds and even quadrupeds and other animals. The more crudely-blotched black and white patterns of certain woodpeckers, the black caps and white cheeks of nuthatches, and the various bold head-markings



FIG. 56. Two artificial butterflies, one dusky and one light, seen against a dusky tree-trunk; the light one conspicuous, the dusky one barely distinguishable.



FIG. 57. The same two artificial butterflies seen against a light background, the dusky one conspicuous, the light one barely distinguishable.

These two pictures show that no *one color* will conceal an animal that must move across the varied and varying face of nature. In our pictures of artificial models we have purposely ignored the factor of *interposed* vegetation, which in nature plays so large a part in abetting 'vanishment' by obliterative costumes. For we are here studying main principles, divested as far as possible of accessories.





FIG. 58. Chestnut-sided Warblers (*Dendroica pensilvanica*). Counter-shading and general-ized obliterative background-picturing patterns. Photographed from nature by Francis H. Herrick. Courtesy also of G. P. Putnam's Sons.



FIG. 59. Chestnut-sided Warbler (*Dendroica pensilvanica*) and Catbird. [C. v. Fig. 58.] Photographed from life by F. H. Herrick. Courtesy also of G. P. Putnam's Sons.

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FIG. 60. Blue Jays at their nest, amid foliage. [See p. 116, Chap. XIX.]



FIG. 61. Chickadee at nest hole. Light-and-shadow-picturing generalized obliterative pattern, most potent in snowy winter. Notice how the black head-markings 'merge' with the dark hole beyond. Photographed from life by Finley and Bohlman. Courtesy also of "The Condor."



FIG. 62. Oystercatcher (*Haematopus ostralegus*) close to its nest on rocky ground. Counter-shading and 'ruptive' pattern, etc.
Photographed from life by Cherry and Richard Kearton. Courtesy also of Cassell & Co.

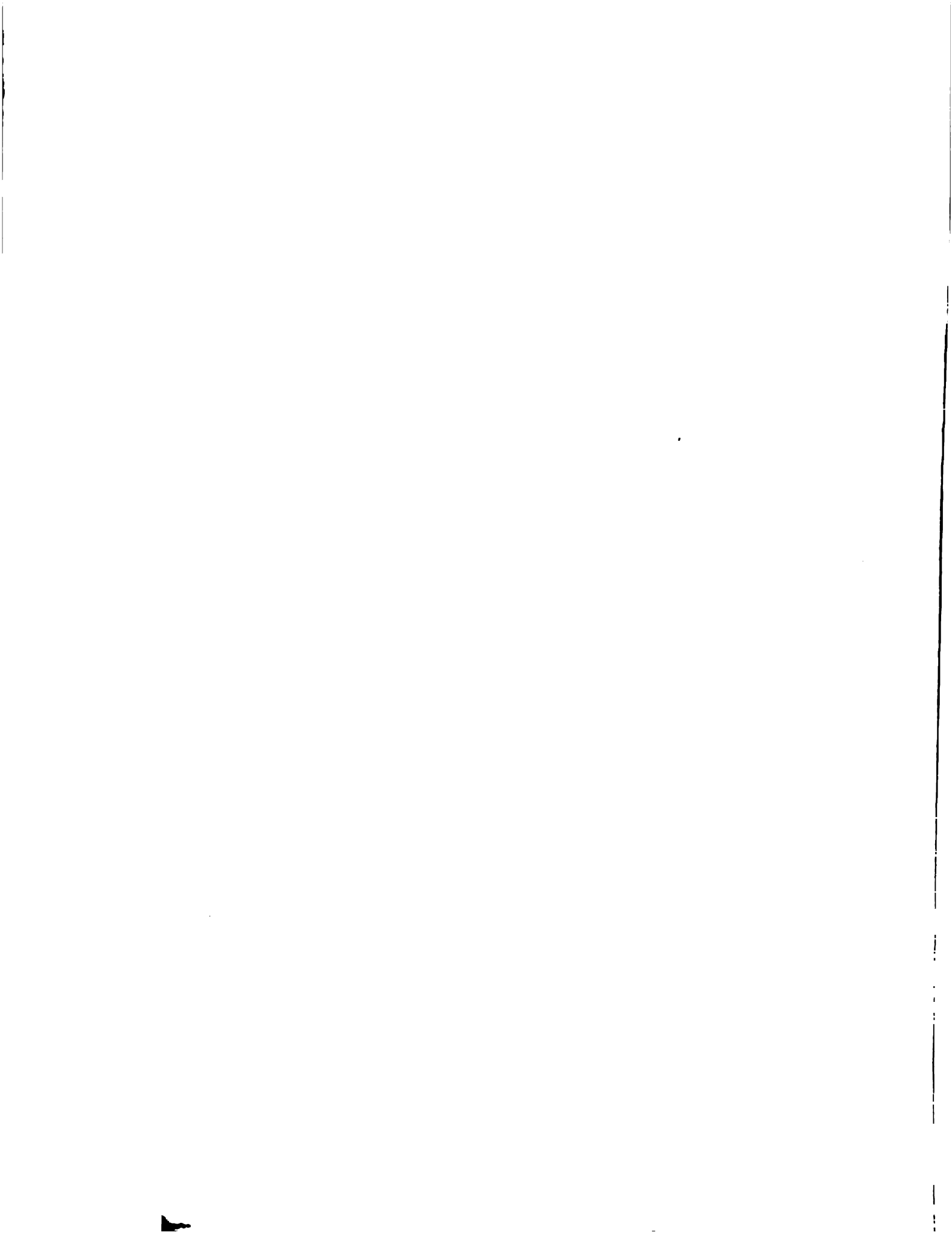




FIG. 63. Fullemoos on rock, showing 'ruffly' coloration. Seen against the sky or (brightly sky-lit sea) they 'lose,' so to speak, their light parts; seen against the shadowed rocks they 'lose' their dark parts, and thus their bird-like contours are disguised.
Photographed from life. Here reproduced through the kindness of Prof. F. A. Lucas.

of North American Wood Warblers (*Mniotiltidae*), are a few of the many examples among the smaller land birds. (See Figs. 58-61.)

It might be supposed that a marking in such rank violation of the paramount 'obliterative' principle as a jet-black breast or belly, with lighter tones above it, could not fail to make a bird exceedingly conspicuous; but this is by no means true. Such a marking, especially when it ends sharply against a lighter tone, thence upward counter shaded, tends in aspect to detach itself from the rest of the bird's dim body, and to unite with the background as a hole or other very dark detail, thereby 'breaking up' its wearer's characteristic form. This is the coloration for instance of the Black-bellied and Golden Plovers (*Charadrius* and *Squatarola*) in summer plumage, and of the adult male Massena Quail (*Cyrtonyx montezumæ* and its subspecies) of Mexico, etc. In the case of such birds as the male Eider Ducks, however, there is virtually no counter shading above or below,—the obliterative scheme consisting almost wholly of a series of 'breakages' achieved by sharply contrasting patches.

All these bolder schemes of pattern mask their wearer in a distant view and in many views, whereas the delicate picture-patterns based on perfect oblitative shading play their full part only in a near view and against one particular type of background. In such a case, details of light-and-shade and minor surface markings count for much. But give the object a greater distance from the beholder, and manifold vicissitudes of position and illumination, and it is *contour* that betrays it—contour, relieving with varying degrees and kinds of conspicuousness against varying backgrounds. Combating this principle, Nature has given many of her animals bold and brilliant 'ruptive' patterns, which insure them, in lieu of elaborate and *single* background-matching, the highest average of *fragmentary* background-matching, in many situations and from many view-points. (See Plates V and VI.)

CHAPTER XIV

SPECIAL FUNCTIONS OF MARKINGS. BIRDS, ETC. PROTECTIVE COLORATION OF NESTLINGS

HEEDING henceforward the axiom established by the foregoing chapters, viz.: *All markings and patterns whatsoever are, under ordinary outdoor conditions, unfavorable to the conspicuousness of the thing that wears them*, we will examine further special phases of disguising-pattern in the costumes of birds and other animals.

A noteworthy type of generalized picture-pattern occurs, the world over, on the wings and tails of hawks and owls. Most of them have, in some plumage, conspicuously banded quills, whose pattern shows to best advantage on the underside. On some kinds, like the Goshawks (*Astur atricapillus* and *A. palumbarius*) in juvenile plumage, these bars on the quill feathers form, when the tail and wings are broadly and fully expanded, a large series of almost complete concentric circles. Potent must be the obliterative effect of such a pattern, to the victim at whom the hawk is dashing, or above whom he is momentarily poised, with widespread tail and wings. The reduplicate circles of alternate light and dark, extending from the hawk's dim, streaked body to the very tip of his great flight-feathers, and averaging more sharply visible than the actual contours of the wings and tail, practically efface those members, so that for an essential instant he is as it were dissolved and blended outward, from a central core, into the banded and streaked promiscuous pattern of the twigs and branches behind and all about him. His menacing body is the inconspicuous center of a maze of forest-colored circles, bewildering and confounding to the terror-stricken creature on whom he is about to pounce. (See Figs. 64-66.) The light bands in these patterns of hawks'



FIG. 64. Stuffed Goshawk (*Astur atricapillus*, young) in winter pine woods, seen from below as the hare or grouse would see him, wonderfully watching, with the help of counter-shading, his barred background of twigs, sky-glints, etc.



FIG. 65. Part of a Goshawk's wing seen from below against pine twigs and sky. [Cf. Figs. 64 and 66.]



FIG. 66. The same young Goshawk (*Astur atricapillus*) laid on its back on the forest floor and looking conspicuously bright. This reveals the part played by counter-shading in the 'twig matching' shown by Figs. 64-65.



FIG. 67. Baby Golden Plover (*Charadrius fulvus*). Counter-shading and blotchy ground-picturing pattern, eye-masking pattern, etc.
 Photographed from life by Cherry and Richard Kearton. Courtesy also of Cassell & Co.



FIG. 68. Ringed Plover (*Aegialitis hiaticula*). Eye-masking and 'obliterative' shadow-and-hole-picturing pattern. His black marks, as the reader will see, ally themselves wonderfully with the dark fissures in his background.
 Photographed from life by Cherry and Richard Kearton. Courtesy also of Cassell & Co.



FIG. 69. Lapwing (*Vanellus capella*) on its nest. Obliterative shading, eye-masking and shadow-picturing obliterative patterns.
 Photographed from life by Cherry and Richard Kearton. Courtesy also of Cassell & Co.

wings and tails are almost always very translucent, and contrast brightly with the opaque dusky bands, even when the wing or tail is seen from below, and deeply shadowed. As the pictures show, the dark marks are just of one 'value' with the darker twigs and branches, and the light bands between of one value with the interspaces of foliage transfused with skylight, against which the branches and twigs 'relieve.'

Another noteworthy detail of the independent efficacy of pattern is the masking of birds' and mammals' eyes.* Markings of this kind occur chiefly on predatory mammals, and on birds. See, for instance, the young plover's head in Fig. 67. Notice the dark ring surrounding the eye, and the longitudinal dark mark at either end of it—a 'stringing out' of the eye's dark tone. Patterns like this, but often bolder and more varied, surround the eyes of many birds and a few quadrupeds. The lengthwise stripe, especially—the dark line which the eye seems scarcely to interrupt—is a very common marking among birds. This seems to be a 'conventionalized' eye-masking pattern, like the conventionalized ground pattern of larks and sparrows. It is very effective, however, as it completely breaks the eye's otherwise conspicuous circular or oval outline. Other, more varied patterns achieve this in a still higher degree, often seeming to absorb the eye into themselves as one of the details of their irregular form. (See Figs. 67-72.) Light-colored eyes,

* Many herbivorous mammals have dark and lustrous eyes, surrounded by a more or less distinct pale-colored ring. This, however, belongs to the obliterative shading, playing its full part of shadow-neutralizing when the eye is shut. Very likely the noticeableness of the open eye does the animal good service when it is skulking, inasmuch as it increases the likelihood that the skulker will know the instant he is surely detected by an enemy. All the rest of him is almost or quite 'obliterated,' but there is still much chance that a predatory creature, hunting by scent as well as by sight, may discover him. Because of this chance, he must be alert, ready to leap and run at any moment, and must keep his eyes open, even though they may help to reveal him. But their very conspicuousness increases the chance that the predator, having followed his quarry up by scent, or coming suddenly upon it, will look first directly at those its points of vital watchfulness, thus giving it the beneficent timely warning—the sure and instant signal that the crouching 'game is up'—which would be lacking if the hunting-beast first recognized some other portion of its quarry's body. Encircling marks and all, the eyes are small details of the 'obliterated' creature, and cannot attract the predator's attention unless he comes almost within striking distance.

especially those with narrowly slit pupils, are often very inconspicuous, in themselves. The green and yellow eyes of many felines, especially when they are surrounded by irregular fur-patterns of about the same shade, are insidiously unapparent and elusive, 'merging' well with leaves and foliage-vistas, etc. This obliterative coloration of cats' and other predatory creatures' very eyeballs must be a great aid to them in their stealthy stalking of their prey. An eye like that of the Copperhead Snake (Chapter XXIV, Plate XI), with its narrowly slit pupil, is as well concealed as any part of the creature's obliteratively colored body.

One more subject which must have a place in this rather miscellaneous chapter is the coloration of birds in downy nestling plumage. Passerine birds—most of them at least—are born naked and absolutely helpless, remaining in this condition for days. But they are almost always domiciled in substantial nests, which in their turn are usually hidden amidst foliage, so that the youngsters are well shielded from their foes. Such birds have no true downy plumage, but pass from nakedness into a coat of frowzy contour-feathers, marked somewhat differently from those of their parents, though often much resembling them. But there is a great group of birds, including most of the members of most of the orders outside of *Passeres*, whose young are born with a full downy covering, which they retain for many days. Such are the grebes, ducks, geese, gulls, terns, rails, shore birds, *Gallinæ* (grouse, etc.), goatsuckers, hawks, owls, etc. Of these the terrestrial (and aquatic) forms concern us most, for they are more exposed to danger, and have more highly developed protective coloration, in the infant state, than the nesters in trees. The terrestrial (and aquatic) assemblage may be again divided into two sections, one including the species whose young are for a time sedentary and helpless, and the other those whose young are active and alert from the moment of birth, and leave the nest almost at once. Of the active sort are grebes, ducks, rails, sandpipers, and all the gallinaceous birds; while goatsuckers, and, to some extent, gulls and terns, belong to the sedentary type. Young grouse and other *Gallinæ* acquire the power of flight, along with con-



FIG. 70. Killdeer Plover on its nest. [Cf. Fig. 71.]
Photographed from life by Dr. Thos. S. Roberts. Courtesy also of "Bird Lore."



FIG. 71. Killdeer Plover over its nest. Obliterative shading, shadow-picturing patterns, etc.
Photographed from life by Dr. T. S. Roberts. Courtesy also of "Bird Lore."





FIG. 73. Nighthawk chick, as in Fig. 74.
Photographed from life by F. H. Herrick.

FIG. 72. Young Killdeer Plover,
wonderfully 'obliterated' by counter-
shading and ground-picturing pattern.
Photographed from life by Finley & Bohlman.



FIG. 74. Nighthawk (*Chordeiles virginianus*) chick—obliteratively-shaded, and further 'merged' into its background by blotchy ground-picturing patterns.

Photographed from life by F. H. Herrick. Courtesy also of G. P. Putnam's Sons.



FIG. 75. Baby Common Gulls (*Larus canus*). Spotty ground-picturing pattern, like the shadows among pebbles, etc. Photographed from life by C. and R. Kearton.



FIG. 76. Baby Curlew. [Cf. Fig. 73.] Photographed from life by C. and R. Kearton. Courtesy also of Cassell & Co.



FIG. 77. Young Crested Grebes. Highly-specialized obliterative picture-pattern (with obliterative shading.) Photographed from life by Cherry and Richard Kearton. Courtesy also of Cassell & Co.



FIG. 78. Baby Red-breasted Mergansers (*Merganser serrator*). Water-shine-and-shadow patterns, etc. Photographed from life by Cherry and Richard Kearton. Courtesy also of Cassell & Co.



FIG. 79. Sketch suggested by the young mergansers in Fig. 78 to show how closely they represent a little wet spot in a swamp.

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FIG. 80. Young Horned Grebes on their nest. Obliterative shading and specialized ground-picturing patterns. [Cf. Fig. 77.]
 Photographed from life by Herbert K. Job.



FIG. 81. Baby Woodcock (*Philohela minor*). Picture-pattern, based on counter-shading. Notice, here and in the next figure, the perfect picturing by these young birds' patterns of dark holes and lighted details.
 Photographed from life by E. G. Tabor.



FIG. 82. Baby Woodcock (*Philohela minor*). [Cf. Fig. 81.]
 Photographed from life by E. G. Tabor.

tour-feathers and elaborate picture-patterns, at a remarkably early age—while they are still mere chicks—but with this and a few smaller exceptions, there is much sameness in the baby plumages of the many members of these widely separated orders. (See Figs. 67 and 72-76.) Pure oblitative shading is universal among them, occurring fully developed even in species whose adult plumages lack it. Their color varies correspondingly to that of their normal surroundings; those which are raised on the rocks, like terns and nighthawks, being grayer, as forest-hatched grouse and whip-poor-wills are browner; but there is a prevailing tone of dim-brown ground-color by which the variations are connected. The *patterns* of these youngsters, too, are nearly all much alike. Grebe chicks, young woodcocks, and some young ducks, with their fantastic oblitative spots and stripings (see Figs. 77-82), are exceptions; but most of the other kinds, from gulls to goatsuckers, wear on their baby-down a soft, blotchy speckling, which seems to be the nearest approach to a near-ground picture that the weak, hairy feathers can produce. But this pattern serves admirably to merge the little, counter-shaded puff of a chick into its immediate background of rock or pebbles or leaf-strewn forest earth. The 'obliteration' indeed, strongly abetted by the chick's form-belying, ambiguous fluffiness, is often perfect. (See Figs. 48, 72, 74, and 82.) Young ducks and geese, living much among green reeds and grasses, are more or less strongly tinted with greenish yellow, but their markings are usually very simple. Baby plovers and sandpipers (Figs. 72 and 76) have a dainty and effective pattern, though still more or less of the blotchily speckled type, and are counter-shaded to a nicety; as are, indeed, almost all terrestrial downy chicks.

CHAPTER XV

BIRDS. OBLITERATIVE COLORATION AND MASKING OF BILL AND FEET FOR OFFENSIVE PURPOSES

UNDER this heading I shall include the pattern-bearing "pantaloons" of hawks, the prevailing pale or bright coloration and occasional counter shading of their tarsi and feet, and the various bright colors and occasional flowerlike appendages of the bills of jacanas, gallinules, anhingas, herons, etc.

The spreading shields of leg feathers, or "pantaloons," worn by almost all hawks and some owls, and almost peculiar to them, must naturally be supposed to have some connection with their predatory grabbing-habits. But what is the connection—what the function of these pantaloons? One use they have, and a seemingly important one, is this: they act as masks of the dangerous talons, by making them appear merely as spots merged into a moving veil of patterned feathers. If the extended legs and feet were stark and narrow, without adornment, they would be much more clearly visible to the animal attacked. As it is, the deadly feet descend in a broad and blurring haze of mottled feathers, which must certainly reduce the victim's chances of successful dodging. The bold form of the hawk's long leg is veiled by these tufted feathers, and still further concealed by the pattern of spots or transverse bars which these feathers bear. On some species, such as the Rough-legged Buzzards (*Archibuteo*) of the North, and the Harpy Hawks (*Spizaetus*) of South America, the entire tarsus is concealed by feathers, usually covered with bold patterns (sharply cut by transverse barrings in the Harpy Hawks); but most species have the tarsus as well as the foot bare for action. Most owls, on the other hand, have everything but the very claws

muffled with feathers. The bare feet of hawks are usually very light in color—yellow or livid green or orange,—oftenest yellow. These pale, bright colors have a deceptive effect, inasmuch as they are less characteristic of hard animal substances than of leaves and flowers and grasses. Furthermore, they tend to prevent the feet from looming darkly conspicuous, as they otherwise would in the shadow of the body. In the case of the Osprey or Fish Hawk (*Pandion*), whose spur-scaled foot has such a marvelous tenacity of grip, Nature seems to have used her utmost skill in the manufacture of a perfect fishing weapon. Not only are the tarsus and toes pale watery blue and green in color, but there is even a perfect obliterative shading from the top to the bottom of the foot. The pantaloons are obsolete, and all the leg feathers are immaculate white—details in most evident harmony with the habits of the bird. Spreading leg feathers would obstruct action in the water, and markings would be equally out of place, since they belong properly to the inhabitants of the streaked and mottled realms of field and forest. Pure white, on the other hand, is less conspicuous than any other tone or color when seen from below against the sky, or against the body of the bird above, whose interposed opacity additionally steepens the leg in shadow.

Of one class with these masking-devices of hawks' legs and feet are the bright and motley bill-colors of predaceous wading birds and swimming birds. Whatever may be their other functions, these gaudy colors well serve to distort, conceal and mask the powerful beaks, to the vision of the fishes, frogs, insects, etc., in the capture of whom they are employed. Some of these beaks, such as those of many herons, of anhingas, etc., are marked with brilliant reed- and water-colors, in various forms and combinations. Others, such as those of rails, gallinules, jacanas, etc., are like bright leaves, stems, or flowers—green, yellow, orange, or scarlet, as the case may be, in varying patterns, sometimes combined with water-like blues or purples. (Certain South American frogs are clad in these same colors. See Belt's "The Naturalist in Nicaragua," p. 321.) Some of the jacanas have flat, erectile lobes or wattles, of a rich red color, set about the base of the yellow bill, like red petals around

a golden corolla.* Many of these wading birds have also reed-colored or otherwise deceptively painted legs and feet, which may often save them from being snapped up by alligators and turtles, and must also help them in their hunting.

The study of the colors of birds' bills and feet in relation to their habits and environments is a large field in itself, and we in this chapter have barely peered over its borders. But there seems little room for doubt that the general principles here briefly stated are dominant or at least very important ones.

* It is most noteworthy that scarlet and yellow, the colors of the flowers and leaf stems of the "cow lilies" which abound in North American swampy ponds, are also to be found on a great many of the animals that resort to these places. The Wood Duck, the Gallinules, the Red-winged Blackbird, and the Painted Tortoise, for instance, all wear scarlet, black (or dark blue) and yellow, just as does the surface of such a pond, with its black shadows between the lily pads and flowers. Even the long-billed Rails of the same region have (in spring and summer) coral-colored beaks. Indeed, red, orange and yellow seem to be very common colors of aquatic vegetation and of swamp birds' beaks, the world over.

From a hawk's point of view, as he flies over swamps and ponds, it is not merely the black water itself that these species match, but also the dark mud, and, in general, the dark spaces between the vegetation. From overhead, the Red-winged Blackbird, even when perched on top of the bushes, matches—or simulates—the shadowy spaces beneath; and his faintly discernible outline is easily rendered indistinguishable by the conspicuousness of his scarlet and yellow cow-lily picture (just as the letters in Fig. 106 are made illegible by their patterns)—in spite of his lack of counter shading. In fact, though the 'Redwing' often perches high enough to show black against the sky, *to us*, to the soaring hawk he is commonly *matched to the mud*, as much as rails or coots.—A. H. T.

CHAPTER XVI

BIRDS, CONTINUED. 'OBLITERATION' BY IRIDESCENCE. CHANGEABLE COLORS IN GENERAL; THEIR PART IN WATER-PICTURING COSTUMES, ETC.

BRILLIANTLY changeable or metallic colors are among the strongest factors in animals' concealment, and go far toward achieving 'obliteration' without counter shading. The quicksilver-like intershifting of many lights and colors, which the slightest motion generates on an iridescent surface, like the back of a bird or the wing of a butterfly, greatly obscures the visibility of that wing or back, as such, tending to make it 'blend' inextricably with the gleaming and scintillating, labyrinthine-shadowed world of wind-swayed leaves and flowers. Even without motion, the animal's surface, which would show all in its true place and plane if it were plainly colored, is by its iridescence made to appear 'dissolved' into many depths and distances. Here is a bright place that stands out near and clear, there a dark area that melts away into indefinite remoteness, and so on. Rarely does such a 'changeable' surface, out of doors, reveal itself fully and truly to the eye. Hence, iridescence is, as I have said, one of the prime factors of disguise, and quantities of creatures profit by it. As a general rule, it is found on animals that spend much of their time in lively motion. As we have seen in Chapter XIII, the more minutely detailed forms of oblitative coloration are not adapted to animals of this type. Seldom "lying close," they need a bold and simple disguise to lessen the conspicuousness of their movements. This is found, as we have seen, in 'ruptive' pattern; and iridescence is equivalent to ruptive pattern with an added gift—the power of motion. Ruptive pattern, that is, with no fixed form, but mutable like the landscape itself.

When the iridescent-costumed animal is still, the slightest change of light upon him will cause a bewildering play and movement of his colors; and when he moves, his colors' varied dancings are far more apt to belie and perhaps conceal his motions, than to accentuate them. For instance, the gleaming highlight, the central point of shine on the back or side of an iridescent bird, say a turkey gobbler or a peacock, may move backward on the bird's surface while the bird himself moves forward, so that to the observer's eye it seems to be standing still, and since by virtue of its very brightness this spot will hold the attention, it must often happen that the bird seems to be motionless when he is in fact slipping away. It may be objected, and truly, that such deceptions as this are of only momentary effect. But the reader should realize, in this case and in all kindred ones, that it is just these tiny, trivial seeming moments that often tip the balance toward escape or capture, toward life or death, in an animal's career. The predatory animals and the animals they prey upon have been developed together, and their powers of capture and escape interadjusted to a nicety. The business of the one kind is to hunt and kill, of the other to evade their clutches; both are Nature's children, both are favored by her, and both grow up and survive as races in the same woods and fields. On the one hand, Nature fits the hunters to kill enough of the weaker animals to keep themselves alive as a race, on the other she fits the weaker ones to escape so often that their race too shall not succumb, that the hunting race cannot overstep its boundaries; that, in short, the even balance between hunters and hunted shall in the long run be maintained. On the hypothesis of Natural Selection, we must suppose that there is the closest rivalry between the two opposed developments; like the continual competition which has long been going on in *man's* domain, between the development of armor and the development of explosives and projectiles. To their rivalry alone is due the wonderful and ever-increasing excellence of both developments, in the case of the human instruments of destruction and defense; and just such, if we believe in Natural Selection—or, in fact, on any hypothesis that recognizes adaptation as something more than accidental—must we sup-

pose to be the way with predators and prey in savage nature. In any case, it is obvious that, as things stand to-day, the very smallest items in aid either of the hunters or the hunted must be of vital importance. Eagles and tigers are not more clever at *catching* than their quarries are at *escaping*, hence the slightest additional aid may save a quarry's life. Just such an aid is the momentary deception effected by the contrary movement of a spot of iridescence, as described above. Hindered but for an instant, the pursuer may be wholly balked, for that instant may enable the quarry to slip into cover, or take wing, just in the nick of time.

But the larger deceptions achieved by iridescence, viz., nearly complete 'obliteration,' in one form or another, are still more potent and important. A brightly changeable plumage is like a sumptuous wardrobe, packed into marvelously small compass—many different dresses combined in one, without the loss of their individual identity. The Mallard Duck (*Anas boschas*), for instance, has in some lights a bright green "speculum" on its wing. In other lights this mark is blue, in still others, purple. In addition to the look of life and motion (like that of water and glittering vegetation) which the changeableness of this marking gives it, it also makes it far likelier to match the bird's background than any fixed tint could. Water, mirroring whatever is above it, varies interminably in color, and so do foliage-vistas and other landscape details. Were the Mallard's speculum of a uniform blue, it would serve its full oblitative use only when the bird's background happened to show areas of just that hue. But containing as it does the whole scale of colors from grass-green to reddish purple, displayed one after another by slight changes in the bird's position, it is equipped for perfect color-matching, if often only in flashes, with many sorts of background. Indeed, even in most single views, and without motion, the speculum shows such a range of lustrous color that some part is likely to be an exact match for one of the background tints. (Although this marking is usually almost hidden while the ducks are swimming, it often comes into full view when they walk or stand, as on river-banks or tussocks, or in reed-grown shallows.) Still more marked

and striking applications of the same principle occur among bright-colored land birds, notably tropical ones. There are species with almost the entire plumage highly iridescent, changing perhaps from bronzy red to emerald green (or even to blue), according to the bird's position relative to the source of light and the beholder. Such for instance are some of those exquisite aberrant kingfishers, the jacamars (*Galbulidae*) of South America. One of them at least, *Galbula ruficauda*, the only kind my father and I have studied in its native forests, is exceedingly hard to discover when it is sitting stock-still on its exposed look-out perch low down among the trees. It affects semi-cleared areas, and the open reaches and borders of the forest, where there is much variety in the colors of its background, and there is no disputing the fact that its beautifully rich iridescence aids it greatly in escaping notice in these places. Its colors shift with the shifting scene, as it were; they counterfeit the airy life and changefulness of the encompassing leafy landscape, played on and vivified by wind and sun and shadow, not to speak of the changes wrought by the movements of the beholder. The environing landscape contains, in one or another degree of purity and brilliance, all the colors of the rainbow; and the tints of the jacamar's plumage likewise range through almost the entire spectrum. Often the bird's background is bluish green, often all his upper parts show nothing but that color; often, again, his background is rich reddish bronze, just such as his feathers show in certain other lights, and so on. Of course the changes in the bird's color are independent of the changes in his background, but in the long run his lively versatility of tint must enable him much oftener to match his versatile background, in part at least, than he could if his colors were unchanging. The jacamar is also a bird of the deep forest, however—not by any means *confined* to the bright-colored half-open regions—and accordingly he wears on his underside the regulation forest brown of tropical woodland animals. (See Chapter XIX, p. 107.) If a bird wears colors characteristic of his environment, it is not necessary for his concealment that he should momentarily 'match' his background, even in part. A spot of brown, for instance, introduced where such

a spot *might well occur* in the background, will readily pass for a real background-detail.

There are two kinds of changeable color among birds. One is iridescent or metallic color, such as we have been considering, and the other, worn by many of the most gorgeous species, is what may be called 'dead' or sheenless, changeable. In this there is no sudden glinting or intricate intershifting of bright colors, but merely a change in the general tint of the lusterless and uniformly-colored surface, dependent on the complete change of its position relative to the source of light. This kind of coloration lacks all the subtler magic of obliterative power possessed by iridescence, but shares to some extent its advantage of adaptability to often-varied backgrounds. Many of the most brilliant blues, greens, and purples in the plumage of birds are of this lusterless type. Good examples among familiar species are the common European Kingfisher (*Alcedo ispida*), and the North American Indigo Bunting (*Passerina cyania*). When such a bird is between the beholder and the source of illumination, its brightest color is a deep blue, or sometimes even purple. When, on the contrary, the beholder has the source of illumination behind him, and the bird in front, so that the light, striking it fully and fairly, is reflected directly back to the eye, the parts which were before dark blue or purple are clear, light green, sometimes even golden green or almost yellow. (For the best effect, particularly in the display of the *green* extreme, the bird should be seen head-on.) Some birds which are wonderfully inconspicuous in their normal haunts have this type of coloration. Such for instance is the American Purple Gallinule (*Tornis martinica*), mentioned in an earlier chapter. The changeableness of this bird's color, however, is mainly from bright to dim, rather than from green to purple, and does not play a very important part in his 'disguisement,' which is nevertheless adequate. It consists in a close imitation of the beautifully blended tints of quiet water amidst luxuriant vegetation. The soft purple breast and sides picture that part of the pool which is shaded from the sky, and reflects almost nothing; the bright-blue wing depicts the water which reflects the sky, and the green and olive back,

into which the wing's color softly blends, is a perfect match for the dim reflections of vegetation at the water's edge. Thus the Purple Gallinule's costume seems to be a picture of the entire surface of a little pool among the reeds. It largely lacks oblitative shading, and its pattern is to some extent of the 'ruptive' type, the 'break' occurring between the dark-purple underside and flanks and the bright-blue wings. This makes the sky reflection seem to stop short, as if against the shadow of a water plant, while the purple pictures a darkly and graduatedly shaded portion of the pool. A kindred type of coloration, but one involving true iridescence, occurs on the American Green Herons (*Butorides*). These birds' costumes have perhaps even closer affinities with that of the Wood Duck, described in Chapter XI. Both haunt opener places than do the gallinules, not being dependent, as they are, on the shelter of the reedy jungle. In this respect, however, the Wood Duck is intermediate between the other two, though nearer to the heron. Green Herons frequent the reaches of open water, and avoid the reeds; but not being swimmers, they are confined to the shores and shallows, and the trees and bushes over them. Characteristically, then, they are birds of the edges of small inland waters. Accordingly, we find them beautifully equipped with water's-edge colors and patterns. Their ash-green, delicately iridescent backs picture the surface of still water, faintly shimmering, and covered with a film of floating dust or scum, which blurs reflections. Their necks and heads, when brown (as in some of the species), match muddy patches on the bank, or mud-holes seen through shallow water, or the interior brownness of the trees and bushes over or beyond the water's edge, or the brown, leafy ground beneath them. But it is on the herons' *wings* that the oblitative picturing reaches its most elaborate development. Their ground-color is a soft, iridescent, water-green, and this is brodered over with a system of delicate marginal stripes and bands of white and buff. These markings are so arranged that they imitate very closely the look of green-reflecting water rolling in small ripples over golden sand—a most characteristic sight at the borders of streams and ponds. The white marks depict the ripples, and the buff

marks the sand glinting through the moving water. Again, the system of white and golden marks together simulates the flickering sun stripes on the bottom, made by refraction from the ripples. Naturally, the life and realism of these pictures are greatly enhanced by the iridescence of the green ground-color.

There are a great many other beautiful cases of this use of iridescence in aid of definite background-picturing, but the above example must suffice us here. One more small detail, however, one more phase of the use of changeable color, must be described. It is one to which I have already alluded, in part, in this and an earlier chapter, namely, the apparent 'opening of windows' in a dull-colored surface by the application of bright spots and stripes. The brightest iridescent and sheenless changeable colors are often set in spots like jewels in an otherwise dull costume. Common and important in the case of birds, this type of coloration is even more so in that of butterflies. But these will be considered later, and we are here concerned with birds alone. Many birds, particularly tropical ones, have such gemlike spots in the midst of somber plumage. Often they are surrounded by dead black, or some very dark tone of brown or gray. This encompassing dusky pattern, being usually quite lusterless, is the same in all lights, while the bright spot in its midst flashes and alters with every little shift of light or movement of the bird or the beholder. Therefore it has the look of a hole in a motionless dark obstruction—a glimpse through a somber shadow—beyond which are seen sky vistas or the flickering light and movement of vegetation. Or, again, the bright spots may pass for moving bits of vegetation relieving against a motionless shadow or hole *behind them*. In either case, the solid form of the bird will be effectually 'cut to pieces.'

To sum up: changeable colors of all sorts strongly tend to conceal the birds that wear them, and *iridescence* is extraordinarily potent in this way. Its power is of two kinds, which are, however, practically inseparable in their working. First, it goes far toward annulling the normal lights and shadows, with their color-effects, of the surface on which it is placed; and second, its

great and vivid versatility of color and shade almost insures the 'matching' of some part of that surface with whatever forms its background. When part of a bird's surface blends thus with his background, the remainder, in most cases, looks un-bird-like.

Iridescence should perhaps be considered second only to oblitative shading as a factor in the disguisement of birds; its universality attests its value.

CHAPTER XVII

BIRDS, CONTINUED. THE 'OBLITERATIVE' POWER OF APPENDAGES. ONE USE OF LONG, BANDED TAILS CONJOINED WITH STREAKED BODIES

SINCE the simple, organic outlines of an animal's body tend to reveal it to the eyes of enemies, Nature has resorted to many devices in order to conceal those outlines. Such are various kinds of bold, contrasting patterns, one of whose main effects is to hide the curved, characteristic forms by *letting into them*, as it were, *bays and notches of the background, of arbitrary shape*. Appendages are exactly the converse of this. They break the normal contours by *extending them irregularly outward*, so that, figuratively speaking, the animal is pulled out of shape and 'bridged over' into its surroundings. "Appendages" include long tails, abnormally extended wing feathers, scapular and other tufts, occipital crests, "beards," etc., and also fleshy outgrowths such as combs and wattles—in short, all superadded external developments, whether of skin or feathers. Many of these devices must have a remarkable concealing-power. Think for instance of the Mexican Quetzal, or Resplendent Trogon (*Pharomacrus mocinno*), with its enormously long, green, drooping tail. How potently delusive to a hawk, flying over a seated trogon, might be this indefinite, smooth extension of its green back into the maze of leafage! Other notable examples are the peacocks and pheasants. In the case of many pheasants an additional peculiar principle comes into play. Their long tails are marked with strong transverse bars, of two or more colors and shades, like stripes of alternate light and shadow on dead leaves or earth, which tend to merge the tails into their backgrounds when the birds are still, and thus contribute largely toward their obliteration. (See Fig. 133, Chapter XXVII, p. 238; Fig. 120, and Chapter XXII, p. 159.) But when such a bird glides for-

ward, the bold transverse bars, being extended *across* the line of motion, make the movement of the tail conspicuous, relatively to that of the longitudinally streaked or finely speckled body ahead of it. By this device the bird's chances of escape from an enemy are decidedly increased. For the predator's eye is drawn to marks *back* of the vital part of his intended victim, which is at the same time rapidly moving forward, hence there is likelihood that he will miss his aim by striking *behind*, perhaps capturing a tail from which the bird tears itself free and escapes.

The practical force of this law of the comparative conspicuousness of transverse and inconspicuousness of lengthwise marks in motion can easily be demonstrated. One should take a ribbon of cloth, or a slender board, and mark half of it (one end) straightly and evenly with lengthwise stripes of several colors (or simple black and white), and the other half with the same colors in transverse bars. Then if the stick or ribbon is drawn smoothly across an opening, through which alone it is seen, its motion will be grossly visible while the banded part is passing, and almost invisible during the passage of the striped half. Motion merely tends to convert lengthwise marks into *lines*, which have little or no visible activity, and may often seem to be passive streaks on the background of the thing that bears them. Hence the elusiveness of gliding *striped* snakes among sticks and grasses, in remarkable contrast to the conspicuous movements of *banded* snakes. (Of this the reader is to hear more in a later chapter.) A practical artificial test of this effect even simpler than that above described, and almost equally effective, can be made with a white string, part of which has been marked with dark spots, and part left blank. The alternate light and dark spots are equivalent to the bands, and the unspotted part is equivalent to the streaks (being, in fact, a single, perfect streak). But the whole proposition is pretty much self-evident, and scarcely calls for demonstration. As a factor in the protection of birds and other animals the principle is of decided importance, and it very likely plays a much larger part than we yet know. Among snakes and long-tailed birds, particularly pheasants, its use is certainly both general and pronounced. On

the other hand, the application of such a principle in Nature is almost always enmeshed and interwoven with that of other principles, and this case is no exception to the rule. The same marks which serve to direct an enemy's attention to the tail when the bird is in motion, also serve, as we have seen, to picture the quiet background when the bird is still. Here, however, we have not the blurring counter-action of two principles, but their full coördinate development and perfect interadjustment. The marks on the bird's tail may be, and often are, beautiful pictures of leaves and sticks and light and shadow, as potently obliterative as any other picture-patterns; this is their function when the bird is "lying close." But the moment he moves they are changed into effective 'target marks.' The transformation is instantaneous and complete; the picture-effect wholly ceases; for leaves and sticks and lights and shadows are never seen to move off suddenly and rapidly over the ground, in a compact, unchanging company. With patterns of lengthwise streaks, on the contrary, there is little visible change between rest and motion, as we have already seen. The longer and straighter are the streaks, the smaller is the visible effect of their lengthwise motion, and *vice versa*. (The two extreme types are of course connected by all manner of intermediates.)

Enormously developed feather-appendages are characteristic of several groups of tropical birds, notably the Birds of Paradise (*Paradiseidae*). Hitherto, it has always been supposed that male birds of paradise represented the very acme of avian conspicuousness; but this belief is curiously wide of the mark. In a museum exhibition box, amid blank walls, one of these richly-colored and sumptuously plumed birds is extremely showy and conspicuous; but why should we infer from this that he must also be conspicuous in life in his native woods? *They* are not monochrome and blank, but, on the contrary, full to overflowing with every possible variation of form and color, produced by the redundant richness of the vegetation, and the numberless vivid and changeable effects of sun and shade. The eye finds it hard or impossible to unravel such a luxuriant labyrinth, to separate and define the boundaries of its individual components. Leaves and stems and trunks and

branches, vines, fruits, and flowers, shade and sunlight—all mix and overlap and intertwine in the most bewildering way. Amidst, against, this intricate tangle, even a simple bird-shaped bird, of uniform color, would be very inconspicuous; while a bird (like some of these birds of paradise) so adorned with grotesque plumes * and bristling, 'hay-stack' tufts of superadded feathers as to have lost almost all semblance of his simple bodily form, would be almost insured against detection as he sat or moved in such a forest maze. His many-colored plumose excrescences would serve with extraordinary efficiency to blend him into his surroundings—here seeming to coalesce with a bunch of gaudy flowers in sunlight, here with shining leaves, and there with a gulf of somber shade. Then, too, all irregular outward extension of a bird's form, amid such surroundings, increases the frequency with which parts of his outline come into actual touch with like or kindred colored details of vegetation, thus obscuring still more potently the bird's real shape. (See Plate VI.)

The three main obliterative agents other than counter shading, which we have now considered, namely, 'ruptive' patterns of boldly contrasting patches of color, iridescence and other changeable color, and appendages, different as they are in form, are yet closely akin to one another in the results they achieve. In one degree or another, in one or another manner, they mask the contour of their wearer, and 'break him up' into his background and surroundings. Kindred in character, the three principles are often combined in application, two or even all three of them frequently occurring in the same costume; and the intricacies of their coadjustment are often very hard to analyze. In the case of certain birds of paradise, all three principles are found in full coördinate development. Male birds of paradise are well known to have remarkable habits of raising and vibrating their plumes, as they sit in small companies, among the females, in certain chosen trees. The observation of this habit has led people, most naturally, to believe that sexual display is the sole or at least the paramount use of the plumes and gaudy colors.

* Some of the big tufts of plumes terminate in such a filmy, hazy spray, that they can scarcely fail, in any view, to seem softly blended into their background.

But the assumption that their use is limited to this one function is based on the strangely mistaken notion that such birds *are conspicuous* in their native woods. The error has been wholly based on theorizing—collectors have *not* found the birds easy to see in their home forests, but, on the contrary, have often testified to the strange illusiveness of certain very gaudy kinds, even relatively to their dull-colored and plumeless females. This has led to the belief that they are conscious of being perilously gaudy, and are therefore wary, and careful to keep themselves concealed amidst foliage, etc.—which is evidently a complete misinterpretation of the case.

The question of how large a share, if any, sexual display has had in developing birds' brilliant colors and elaborate appendages cannot be discussed here. But we have at least shown that such developments, far from making birds conspicuous, are all—pied-patterns, iridescence, and appendages—potent factors in the concealment of their wearers. Even the lesser appendages, such as small occipital crests, ear-tufts, wattles, etc., all tend to conceal birds by breaking their normal contours.

CHAPTER XVIII

BIRDS, CONTINUED. MISCELLANY. MIMICRY AMONG BIRDS. THE BRILLIANT, FLOWERLIKE COLORATION OF HUMMINGBIRDS' HEADS NOT MIMETIC. SEXUAL DIFFERENCES OF COLORATION

TWO kinds of 'Mimicry' have been described by various authors as occurring among birds; first, the form distinguished as "Protective Resemblance," in which a live animal counterfeits the appearance of an inanimate thing, and second, so-called Mimicry proper, in which one animal counterfeits the appearance of another. But of Mimicry proper among birds few instances have been cited, while Protective Resemblance has been supposed to cover most branches of avian (as well as mammalian, insectile, etc.) protective coloration, including the many which we have already shown to belong to the very different principle of oblitative coloration. The question of "protective resemblance," indeed—the mimicry by animate of inanimate things—is somewhat closely involved with certain phases of the oblitative coloration of birds, and must be considered here. I have mentioned it several times in the preceding chapters, in connection, for instance, with bitterns, goatsuckers, ruffed grouse and screech owls. In all these cases, the principle has either been dismissed as having no true application, or has been shown to be subordinate to the laws of oblitative coloration. The ruffed grouse and the screech owl draw their feathers tightly to the body, making themselves as thin and sticklike as possible—and this might be called mimicry. But, as I have explained, this very action is essential to the perfecting of their exquisite picture-patterns, which imitate the details of their more or less distant backgrounds, rather than the markings on a single foreground branch or stub. The bittern, likewise, with head and neck held stiffly upright, might be supposed to be mimicking a stick, but a more critical in-

spection reveals the fact that his head and neck picture several reed stems, with their shadows, and that the peculiar attitude is necessary for the most effective display of this obliterative or at most semi-mimetic pattern. (Semi-mimetic, inasmuch as the several reeds seem to occupy about the space really filled by the bittern's neck, although the effect is still of the neck's dissolution into its general background and surroundings.) But in all or most such cases, in spite of the evident paramount importance of the *obliterative* function, it is undeniable that the mimetic effect is sometimes achieved, to a greater or less extent, and hence that it must be a factor in the development of the peculiar actions and even the particular coloration of certain birds. Just how large or how small a factor, who shall say (?); but recognizing the dominant importance of the *obliterative* laws even in these few special cases, one cannot suppose that the other principle has more than a very limited and slender scope. Nevertheless, it is not to be ignored. A Ruffed Grouse picking buds high up among the leafless twigs of winter trees, must often be seen in a light and against a background (as of blank snow) which does not favor its obliterative coloration. Then the extraordinarily slender, stick-like form (accentuated by peculiar angles in the head and neck, and by the erected occipital crest) which the bird assumes the moment it is alarmed, does certainly render it good service in the direction of protective 'mimicry.' At such times the bird's enemies must often mistake him for a knotted branch. Yet, on the other hand, even at such times, thanks to the bird's perfect obliterative shading and pattern, the chance is great that he *will not be seen at all* (as a solid object), and this chance is probably still of paramount importance.

But there is one bird at least in whose case the balance of importance may tip toward the *mimetic* function of specialized perching-habits. This is the big woodland goatsucker of northern South America, etc., the "Poor-me-one" of Trinidad negroes (*Nyctibius jamaicensis*), whose characteristic perching place, both by day and night, is the top of a broken stump or upright branch. Here it sits almost erect, and motionless, with its long and ample tail pressed flat against the side of its perch, which seems to be con-

tinued upward by the bird's dark, obscurely mottled body, terminating in the broad, flat head. This mimetic attitude is completely effective in the twilight or moonlight, when the "Poor-me-one" uses a stump-top as a look-out perch, whence it launches forth on short flights after aerial insects, soon sailing back to cap the same or sometimes a neighboring stub. There can be no doubt as to the completeness and importance of the mimetic function of the "Poor-me-one's" peculiar perching-habits. The mimicry, however, is mainly positional, or attitudinal, for it is not supported by any very particular developments of the bird's form or markings. The bird's mottled pattern, to be sure, is less exquisitely fine than that of many nearly related goatsuckers, and hence less well fitted to serve the full obliterative function of *background-picturing*, while it must greatly help the stump-top mimicry, especially in a dim light. "Poor-me-ones" have been found roosting in the daytime on the tops of stumps, in the characteristic erect attitude, and in these cases they were certainly "making a bid" for mimicry, in which both color and markings played a part. But it is likely that their roosting-habits vary somewhat, as I know that their nocturnal perching habits do. They have a strong preference for naked stumps, but I have more than once seen them sitting in the moonlight on horizontal leafy boughs, and even perching lightly among the slenderest twigs at the very tips of the branches. Assuming that there is equal irregularity in their diurnal roosting habits, as we may pretty safely do, it follows that they must often be so situated that the obliterative function of their coloration comes fully into play. Indeed, there can be no doubt of this, as they are equipped with a complete, though slight, obliterative shading, which hinders rather than helps the mimetic effect; and their markings, though relatively somewhat crude, yet partake largely of all the elements of background-picturing. But, from all that we yet know of the habits of this interesting bird, it seems probable that it profits at least as much by out-and-out mimicry (in effect) as by obliteration. This is the most pronounced case of the kind that we happen to know of. Others equally remarkable exist, no doubt; but they are rare enough to be fairly called anomalous. On the

other hand, the cases are many of the occasional mimetic aspect of birds whose main protective equipment is purely obliterative, like the ruffed grouse, screech owl, etc., just referred to, and the terrestrial goatsuckers mentioned in an earlier chapter. Other slight and dubious encroachments of mimicry into the domain of obliterative coloration have been mentioned here and there in the foregoing pages, as for instance in connection with the flowerlike bills and frontal appendages of certain water birds (Chapter XV).

The gorgeous "beauty spots" of hummingbirds, most commonly occurring on the head and throat, are certainly not mimetic, though they have sometimes been considered so. Flowerlike though many of these brilliant head-dresses are, there is not, I believe, one among them all which really imitates a single flower, in minute and near detail. On the contrary, they are all flashing pictures of *flowery and leafy landscape*, at uncertain distances. Hummingbirds' metallic colors mark the very climax of the development of iridescence, the high obliterative power of which principle has already been explained. Their changeableness often ranges from dull, velvety soot-color to the intensest gleaming of pure red, blue, green, orange or purple, as the case may be; and sometimes several of these bright colors coexist in the same feathers, showing either separately, in different lights, or intermixed, in one light. But the change from one bright color to another is less characteristic of hummingbirds' iridescence than the change from dull black to keenest brightness. It is in the fullness of this change, and the extreme brilliancy of the high-light tints, that the supremacy of their coloration lies. Perhaps, after all, they do not quite deserve the palm for *iridescence*, in the strict sense of the word, but for *changeable* and *luminously brilliant* color, they are almost unique among animals. Indeed, they have an almost unrivaled obliterative equipment. Behind the dazzling, scintillating blaze of its jeweled head, how can the little round body of a hummingbird be seen? That shifty blaze of red or green or purple light, one instant partly clouded over, and in the next flashing out into the sharpest sunlike sparkles, completely eclipses and masks the form and solidity of the body, now veiling it, and now piercing it, so to

speak, with all manner of rents, and vistas of its brilliant, sunlit background, utterly bewildering to the beholder.

It is a noteworthy fact, and an interesting theme for study, that the bright colors of almost all hummingbirds are only revealed, or at least only revealed in their full power, when the birds are seen head-on and facing into the light. This is true, indeed, with many other birds of changeable color, but in no other group is it nearly so marked as among the hummingbirds. Many of their brightest "beauty spots" are dead and dusky except in full front view and lighting. This fact has an interesting bearing on the question of the special uses of hummingbirds' glorious plumage, and suggests several additional possibilities. One of these is that their obliterative coloring is addressed primarily to insects on the flowers and leaves before which they hover, and is therefore offensive rather than defensive. Hummingbirds are so small and lightning-swift that it must be nearly impossible for any predatory birds or beasts to catch them. Tree lizards and small hawks may occasionally seize them while they are perching, although they usually (?) sit on bare, isolated twigs, and are extremely watchful. This watchfulness, however, seems to be directed mainly against other members of their kind (i. e., other hummingbirds, of whatever species), and is aggressive rather than defensive. They are, as is well known, extraordinarily pugnacious, and where several congregate they are continually chasing one another. Nor is this strange animosity exercised solely against their own kindred; with equal frenzy they dart at flycatchers, hawks, eagles,—any flying bird, either big or small, that enters their domain. On the whole, it must be assumed that they enjoy a comparative freedom from the dangers that beset most of the smaller birds. Yet their obliterative equipment is among the finest, and must be of great importance to them. The effulgent, steely brightness of their head-colors, often extended outward by erectile tufts and crests, and showing only in full front view, undoubtedly serves to 'veil' them from the sight of insects lurking in and upon leaves and flowers. Without such adornment, the birds would loom up darkly solid between their little victims and the light, thus warning

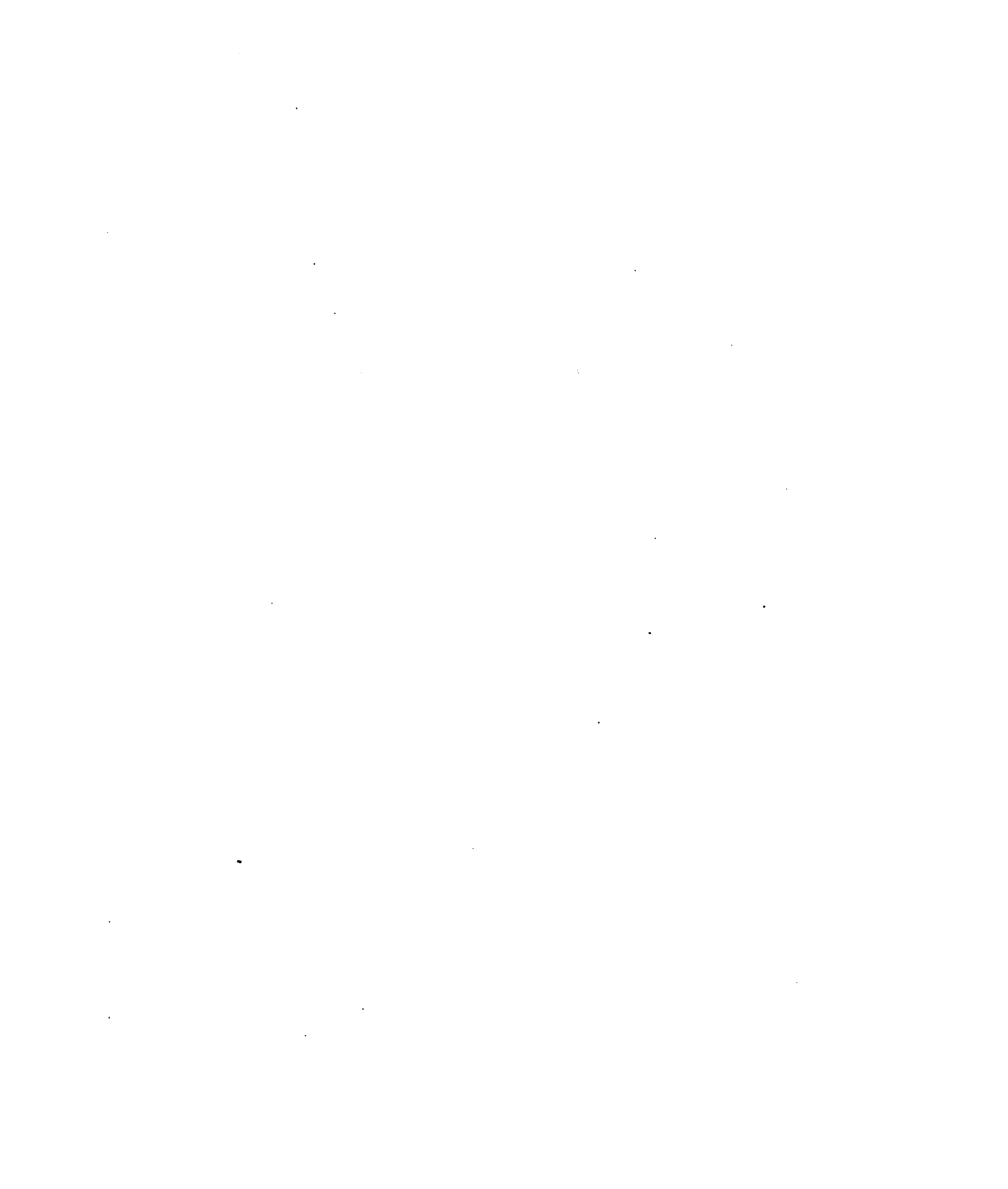
them and giving them a moment's grace for taking flight or crawling out of reach. But their marvelous headgear masks their menacing solid forms. Irradiated, as it often is, by sunlight, it matches the bright, gaudy background of flowers, leaves and sky, piercing and obliterating the interposed bird-bodies. As, from moment to moment, the bright real scene beyond flashes and twinkles and changes, so the mock scene on the hummingbird's front sparkles and shifts with his every slightest movement, and every flicker of the light that vivifies it.*

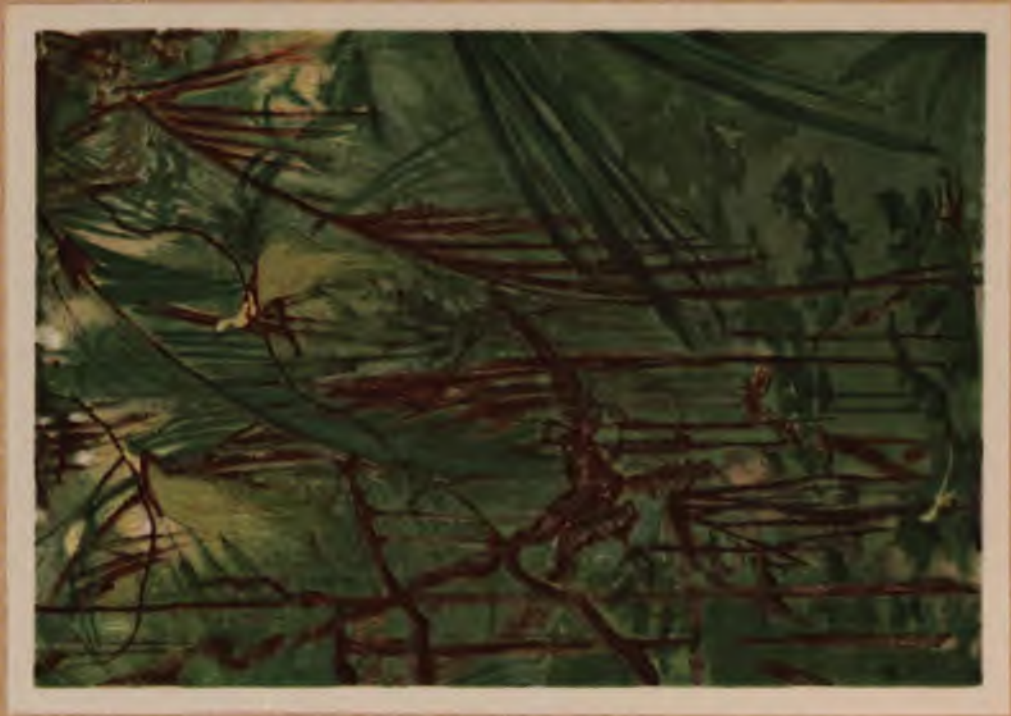
It is needless to discuss here the meaning of hummingbirds' many remarkable appendages, inasmuch as the high obliterative value of such developments in general has already been explained.

Male and female hummingbirds are usually unlike in plumage, and their differences correspond to those of most other forest birds. Furthermore, they are in close and evident accord with the differences in the *habits* of the sexes. The female sits on her neat, moss-trimmed nest, in a shady place, while her mate is buzzing around among the flowers and sunbeams. The bodies, even of the males, are usually equipped with obliterative shading, and the females almost always have it in full development. They are dim in color, relatively to their mates, being mainly soft (but often metallic) green, brown, or gray, and rarely having any fully developed gemlike spots or plumes,—all of which

* A probable minor function of this flashing headgear, under the very same conditions, is the *illumination, by reflected light, of the calyxes of flowers*, and the shaded sides of leaves, which the hovering hummers probe and search. They carry, as it were, little colored lanterns on their heads, whose disk of blue or green or red or purple light can be thrown deep into a tubular flower, or moved up and down and back and forth across a dusky leaf. When any of the very bright ones among these gaudy little 'reflectors' are played on by bright sunlight, and headed more or less directly sunward, they cast a really illuminating glow, which can scarcely fail to be of service to the hummers in their insect-hunting. Again, it is likely that the flaming head-dresses of these little birds—as also the erectile crests of flycatchers—sometimes act as "war paint." When a male hummer leaves his hovering and perching amidst flowers, where his colors are potently obliterative, and launches forth into free air, often above the tree-tops, in violent pursuit of another bird, his fiery-flashing brilliance may well cooperate with the arrowy vehemence of his attack in frightening the object of his anger. Far oftener, however, it must tend rather to dazzle and stupefy the persecuted bird, and, by its incessantly varied gleaming, to bewilder him as to the exact position of the chaser.

is in evident harmony with their habits. For, as with other female birds, one of the most critical periods of their lives is the time of brooding, when, hour after hour and day after day, they have to sit on top of their open nests, in quiet, steady-lighted nooks. Even when, as is usually the case, the females as well as the males *feed* in the gay, sunlit upper border of the forest, they descend into the shady underworld to nest. Hence the fitness of their being softly colored and delicately counter shaded, while their mates are adorned with magnificent jewel-spots and strange appendages. In this matter hummingbirds will serve to exemplify the whole group of forest birds in which the sexes are decidedly unlike. The female, almost without exception, is colored and shaded in the way which best conceals her while she is brooding; whereas the male is colored for active life among the leaves and flowers. Corresponding sexual differences of habits and plumage occur among other than woodland birds. Those of ducks I have already mentioned.





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BIRDS OF PARADISE IN THE FOREST.

Sketch by E. B. Thayer and A. H. Thayer

In this picture the bird's four color-notes have served, by suitable rearranging, to render the whole forest scene itself; showing that the Bird of Paradise, too, has a consummate obliterative costume—one made wholly of the color-notes of a typical scene in tropic woods. Long, sprayey plumes, moreover, are the acme of contour-masking, carrying the bird's form, as it were, imperceptibly into the scenery—the extreme reverse of showing its silhouette. Beyond a certain distance all objects show mainly by their silhouette.

BLUE JAYS IN WINTER.

Sketched from a stuffed bird, outdoors, by Abbott H. Thayer.

A study of stuffed Blue Jays placed out of doors among bare trees over snow. In such a situation the Jay's representation of sunlit snow, tree-shadows, and tree-stems is perfect.—A. H. T.

CHAPTER XIX

BIRDS, CONCLUDED. VARIOUSLY INVOLVED PRINCIPLES OF PROTECTIVE COLORATION OF THE BIRDS OF TROPICAL FORESTS. WINTER BIRDS OF THE SNOWY NORTH. CONCLUDING REMARKS ON BIRDS

THE dim, brown underworld of tropical forests is tenanted by a race of birds and beasts which show a wonderful uniformity in coloration and degree of counter shading. The daylight in these solemn depths is diffuse and weak; hence the animals which live in them are as a rule very slightly shaded from dark to light, and many have pale-brown undersides. Brown is their prevailing color, and there is one particular tone of rich chestnut-brown which occurs almost unvaried on many hundred species. Such sameness of coloration is remarkable; but it is in perfect keeping with the monotony of the realm in which the creatures live. Almost nowhere else can one find such a widely extended prevalence, throughout the year, of a particular degree of light and a few simple tones of color, as exists inside the shell of the great tropical forests. On the *outside* of that shell everything is different. There, in the blazing sunshine toward which the closely crowded trees and vines are ever struggling, the victors heave their leafy heads, flashing and dancing with a thousand tints of gold and green and sky-reflected blue—jeweled with gorgeous fruits and flowers. In this gay realm of scintillating lights and colors live almost all the brilliant birds and butterflies, for which the tropics are famous; and they are as closely fitted to their environment in colors and patterns as are their dull-brown relatives of the somber shades below. The tropics are as rich in dull-colored birds and butterflies as in bright ones; but the dull kinds are not often collected and exported except by naturalists, and do not attract popular attention.

The transition from the tree-top to the ground type, in habits and in coloration, is beautifully gradual and consistent. Blue—clear, skyey blue—

plays a large part in the costumes of the true tree-top perchers. (*Vide*, in our northern American fauna, the Indigo Bunting and the Bluebird.) With it are combined red, green, yellow, and all the other bright colors, in sharp ruptive patches, picturing, in general, the sunlit forest crown seen from above. One step below these 'perchers in air' live the *skulking* tree-top birds, as it were the rails and gallinules of the forest's crown. These live among and beneath the outermost leaves, immersed in a deep bath of green light; and many, though not all of them, are mainly or wholly green. Such, preëminently, are the parrots, those queer and splendid geniuses of the tropic woods. They crawl about through the forest's crown, and comparatively seldom sit on bare, high perches. When they do so they are of course inconspicuous enough against the tree-tops; but many of them lack the finer developments of sky-matching and more generalized background-matching costume. Instead they are attired to match the leaves and flowers among which they are feeding. They are obliterated, almost all of them, but faintly, in keeping with the diffuseness of their usual leaf-dimmed illumination, and their acrobatic feeding-habits, which put them into all sorts of irregular positions relative to the sky-light. There is almost certainly a significant connection, too, between their habit of feeding head-downward, and their gayly blossom-colored tails. Poked up above the feeding parrot's line of watchfulness, and often into the stratum of gaudy flowers and fruits, this tail must have the best possible disguise if its owner is not to be pounced upon from above by some swift hawk. So it is done out into brilliantly disruptive and oblitative spots and patches of rich flower- and fruit- and sky- and sunlit- foliage-colors,—“conspicuously ornamented,” as people used to say. In fact, it is doubtless, under the normal, appropriate conditions, a very mask of masks. Fitly colored for inconspicuousness above the 'green-bath' region, it is scarcely less so for the midmost recesses of that region itself, because the all-suffusing greenness greatly dims the brightest contrasting hues, bringing the red, yellow or purple patches of a gaudy-motley bird nearly or quite into unison with the variations of interior vegetation colors. Thus it is not strange

that some of the typically 'skulking' tree-top haunters of the tropics are most gaudily 'patched,' more so even than the parrots, and that many of the brightest colored 'high-perchers' spend much time fairly *amid* the foliage. But pure leaf-green is the *prevailing* color of the tree-top foliage haunters, just as rich brown is that of the forest ground birds. Between these two types again there are perfect intermediates. Such is the motmot, with its ground-brown underside, its soft green back, and its black and bright-blue head; such also is the beautiful jacamar, described in Chapter XVI (p. 90), and such are some of the dim-colored, low-ranging hummingbirds. The toucans, also, with their great amount of sharply defined black, are best fitted for obliteration in the intermediate woodland realms, where darkly shadowed big branches and tree trunks contrast with sun-spots and gay vistas. But they are also tree-top birds, high-perchers, and their vividly patched costumes of course stand them in good stead in these situations also, in spite of the redundant black. This usually covers the head, back, wings and tail; while the underside is marked with big patches of bright color—red, orange, yellow, white—sometimes all four together—more or less blended into one another, but ending sharply against the black. The huge but almost weightless bill also is brilliantly adorned with yellow, white, or flaming orange, in bold bands and stripes, and the naked skin around the eye is usually bright colored—blue-purple, peacock-blue, or green. Truly, toucans are gorgeous birds! But it by no means follows that they are *conspicuous* in their native woods! Not even though they are vociferous and active, and often alight on exposed tree-top perches. Here or lower down in the forest, their gaudy 'ruptive' patterns 'break them all to pieces,' and though the predator at whose approach they 'freeze' into rigid stillness may espy the black piece, or the red piece, or the yellow or the blue piece, he is still far from sure to recognize his quarry, for none of these pieces has the form of a bird. So with the colors of the tanagers, the birds of paradise, the macaws, and all the rest of the brilliantly pied tropical forest birds, many of which range, like the toucans, from the upper border of the forest underworld to

the airy tree-tops. The frequent black in their costumes, though it often fits in very well with their tree-top background-picturing and 'ruptive' patterns, seems on the whole to be a concession to the time they spend among dark trunks and branches fairly within the forest. Practically all these party-colored tropical birds have counter shading, in the main relations of their colors, however much its smooth gradation is broken and interrupted by the bold patterns, and however irregular and acrobatic may be their feeding-postures. The multiplicity and variety of bright-colored vegetable forms in the sunlit crown of a tropical forest make a great variety of 'ruptive' patterns and colors effective for the disguisement of its birds. As has been told in an earlier chapter, ruptive patterns are often intricately commingled both with iridescence and with appendages, all three factors working toward the one end, '*obliteration.*' It is in the tropics,—in the tree-tops and in the forest-borders—that we find the highest development of all three principles, both separate and combined. Iridescence is not second in importance to ruptive pattern, nor is it less widely and variously used. Appendages also play a very important part, as we have shown.

One more component principle of 'ruptive' coloration, prominent in the costumes of tropical wood-birds, must be here explained. This is the frequent juxtaposition of complementary colors. Just as brilliant iridescence tends to range from one color to its full opposite, or "complementary"—as from red to green—so, when two bright colors occur side by side in a ruptive pattern, they are usually not kindred, but *complementary*. Thus we find green-breasted trogons with red bellies, purplish-blue-breasted trogons with orange bellies, orange-yellow tanagers with steel-purple backs, and so on. Not only are the colors thus placed intensified by mutual contrast, but, by the very added sharpness of their difference, the 'disruptive' effect is heightened. The opposed patches seem less than ever to belong to one and the same object. A bright color tends even to *create* its complementary.* Look at a rich yellow flower, or some other small yellow object, against white paper.

* See the footnote on p. 19, Chapter I.

The white next the yellow seems to glow with *purple*, yellow's opposite. By the same token, two actual complementary colors side by side are much more powerfully brilliant than two kindred ones so placed. This law has yet other bearings on our present subject. It tends to explain the otherwise somewhat anomalous bright red of certain strictly foliage-haunting birds, like the several tanagers and trogons. How can such birds, living almost always among green leaves, in a bath of green light, profit by wearing the most vivid red, the diametric opposite of foliage-color? The answer, *in part*, is this: *dimmed by the strong bath of green light*, the bird's red, actually brilliant, looks barely brighter than many of the glowing brown interstices, the paler shadows on dead leaves, twigs and tree trunks amidst the verdant foliage. Even brown dead leaves *most* favorably situated for showing off their color amidst live foliage are brighter than bright-red tanagers or trogons *least* favorably situated for display against a like background. Also, there are, commonly, many diseased leaves amid the foliage with red as bright as the birds'. But there is no denying the fact that some of these birds, for instance the northern Scarlet Tanager, are more conspicuous in the green woods than their foliage-colored kindred. On the other hand, again, it is true that bright, strongly contrasted hues, and red among the rest, well serve to produce 'ruptive' effects in the color-neutralizing, deeply green-steeped light of the leafy labyrinth in which such birds live, where dimmer tints could not hold their own. This is the way with the beautiful red-and-green trogons, which are by no means easy to discover in their native woods, though vociferous and tame. In tropical as in temperate woodlands, however, the smaller gleaning birds and flycatchers of the shaded lower leafage are characteristically green and yellow and olive, without very bold markings. They live fairly *hidden* amidst shaded foliage, so that dim leaves in a near view, undiversified by other landscape-details, form their normal background. In his admirable paper on the birds of Trinidad, at the mouth of the Orinoco River,* Mr. F. M. Chapman, the American nat-

* "On the Birds of the Island of Trinidad," Bulletin of the American Museum of Natural History, vol. vi, 1894.

uralist, has two pages of very interesting discourse on the color relation between birds and their surroundings in the wild-woods of that island. He fully saw and described the distinctness of the three main color-classes of tropical forest birds, the brown, the green, and the gaudy-motley, each with its own appropriate local habitat. Much of what I have said on this immediate theme is scarcely more than an echo of Mr. Chapman's words, though based on our own subsequent investigations in the same island forests. Limited as they are in extent, the primeval woods of Trinidad are doubtless fairly representative in character of the great South American tropical forests, and, by the same token, of all the humid tropical forests of the world. For, as we learn from traveled naturalists, tropical "high woods" are all much alike in their main general characteristics. Just how largely this likeness extends to the general habits and disguising-equipments of the forest birds, we, personally, cannot say; but there is every reason to suppose that the main principles are the same among the birds of tropical Asia, Africa, and Malaysia, as among those of tropical America. Indeed, a study of tropical birds in museums, and of the writings of naturalist travelers, leaves one with little doubt on this score.

In the matter of local habitat, Chapman divides the forest birds of Trinidad (and hence of all tropical America) into five groups, namely, those of the tree-tops, those of the shaded foliage below the tree-tops, those of the tree trunks below the foliage, those of the bushes and scrub at the forest's border, and those of the ground. The first and second groups comprise respectively the gaudy and the green birds, as has been told. The three remaining groups Chapman lumps as *brown* birds. This will do for a very general classification, but it seems to me that while the scansorial and terrestrial species may well be classed together, the scrub birds should be separated from them. For, many of these scrub-birds, as Chapman intimates, lack the characteristic forest brown, or have in addition a large share of other colors. Their 'class,' however, is laxer and more irregular than the rest, and its special characters are harder to define. Both in habits and in color-

tion, its species grade into other classes, not only of forest birds, but of the birds of the open land, the reed swamps, bush swamps, and river banks, where still other systems of coloration come into play. Thus there are 'brush-birds' which have also a liking for spots of bare, open ground, and have acquired markings much like those of larks and other field birds of the North. Characteristically, however, they are somewhat boldly mottled, with much black and white and ash color; 'pictures' (to be seen in the dim light of the interiors of bushes) of sky vistas overlaced with obstructing, shadowed leaves and branches. Some of those which frequent river banks, like certain Ant-birds of South America, are often marked with the water-shine punctations described in Chapter XI, on a ground-color of muddy gray or brown, obliteratedly shaded. But the vagaries of this none too sharply defined class cannot be described in detail here. The species which constitute it are less typically birds of the forest than of the brush-lands outside the forest. Nor are they, as a color-class, peculiarly characteristic of the tropics, being scarcely separable from the brush-birds of temperate climes. True, the brown, green and gaudy classes are also represented in northern woodlands, but by no means in such full and special development as they have attained in the teeming tropics.

In the snowy northern winter, on the other hand, where the avifauna is extremely meager, we see special color-adaptation reduced to its simplest terms. The costumes of the few birds which pass the winter in the snowy northern forests, deciduous or evergreen, are, it is evident, specially fitted to that season of the year. Some of these birds even, like several of the boreal mammals, turn white at the approach of winter, resuming their gray or brown mottled plumage in the spring. Such are the ptarmigans, described in Chapter VII. But most of the species either keep the same coloration throughout the year, or merely become somewhat paler and dimmer in the autumn, gradually brightening, by the erosion of the feather-tips, through the winter and spring. But even those which do not change color are best equipped for concealment in the winter—the dangerous time of leafless woods and keenly

hungry birds and beasts of prey. One of the most patent signs of this is the great prevalence of white in their costumes. The Snowy Owl, for instance, the chief rapacious bird of the high north, is white (more or less profusely flecked or barred with sooty brown) throughout the year. During the few weeks of arctic summer, when it hunts and nests on mossy, treeless tundras or barrens, it must be a conspicuous object when seen from above against the ground (although even then it may often be mistaken for a scrap of lingering snow or ice). But it has little or nothing to fear from predaceous enemies, and its summer diet consists chiefly of lemmings and other small mammals which live on the open ground, so that the owl always appears above them, against the sky; hence white serves it as it serves the seafaring terns and gulls (Chapter XII) and the partly white-masked mammals to be described in a later chapter. Another northern bird, colored almost exactly like the Snowy Owl, and with kindred habits, is the White Gerfalcon. In addition to these more or less predominantly white birds (ptarmigans, owls, and falcons), many of the smaller species of the winter North are largely *marked* with white (irrespective of their oblitative white undersides). Noteworthy among these are the woodpeckers, titmice, some of the *Fringillidae*, and two or three of the *Corvidae* (namely, the magpies and the North American Blue Jay). Most of them wear a pied or boldly speckled pattern of black and white, which reaches its highest development on some of the woodpeckers, as the Hairy and Downy (*Dryobates villosus* and *D. pubescens*) of America, and the Great-spotted and White-backed (*Picus major* and *P. leuconotus*) of Europe. These woodpeckers are in fact covered with adequate generalized pictures of bits of winter landscape, where dark tree trunks and branches relieve against the snow or sky. Fig. 83 (photographed from a picture made by combining a real Hairy Woodpecker's skin with a painting of a winter-forest landscape) will tell the reader more than many words. Even in summer, though less wonderfully fitted to the landscape, these woodpeckers are far from being conspicuous birds. The larger outstanding spots of white still often pass for glints of sky seen through the



FIG. 83. Hairy Woodpecker (*Dryobates villosus*) in winter woods. [See p. 114, Chap. XIX.] Photograph of a stuffed skin against a painted landscape. Scene copied, 'tone' for 'tone,' not from the woods, but from the woodpecker. The reader must judge for himself as to its realism.



forest, while the smaller ones, and under some conditions the larger ones too, produce a mottled effect much like that of the tree trunks on which the birds climb. (See Chapter VIII, p. 50.) Significant in connection with the evident winter-picturing in the costumes of these northern woodpeckers is the different coloration of their southern relatives. The Downy and Hairy Woodpeckers are distributed from the southern United States almost to the northern limit of tree-growth, and being non-migratory, have developed certain geographical racial differences. The birds of the northernmost race are biggest and *whitest*, those of the southernmost, smallest and *blackest*. Other species of the same genus, and of nearly allied genera, which are peculiar to the southern part of the country, below the limit of snow, lack the larger white blotches, being for the most part closely barred and speckled, in 'tree-bark patterns.' The Golden-winged Woodpecker (*Colaptes auratus*, etc.), which is mainly brown and black and yellow, abounds in the northeastern United States during the summer, but migrates southward in the fall, for the most part keeping outside the snow-line. Looking still farther south, to the American tropics, we find the woodpeckers brown and red and yellow and gray and olive, and, with a few exceptions, almost entirely devoid of white. Many of the tropical woodpeckers, indeed, and their allies in habits the Wood Creepers (*Dendrocolaptidae*), belong strictly to the class of tropical 'brown birds' described earlier in this chapter.

The northern tits and nuthatches are colored much like the northern woodpeckers, but in simple, bold, undiversified 'ruptive' patterns. (See Fig. 61.) So also with the magpies, which have the added gift of rich iridescent color in the tail and wings,—picturing snow-shadows and fir foliage.

The costume of the beautiful Blue Jay (*Cyanocitta cristata*) is a wonderful picture of a winter landscape—snow in shadow, snow in sunlight, sky, trees, and vinous-gray scrub—all are there, in true and exquisite comminglement. Here again we have a picture to show in aid of unconvincing words. The Blue Jay picture in Plate VI, unlike the woodpecker figure, was painted from bird-skins against a real out-door background. Of course the Blue

Jay's costume is not confined to this one kind of background-matching. It pictures, perhaps equally well, a much nearer bit of snowy ground, thickly fretted with blue shadows, with some dark twigs or branches relieving against it. Wherever the bird alights in the winter woods, he looks like a vista through the tree in which he sits to one or another of these blue and snow-bright backgrounds. He bears a full oblitative shading (from dark blue and black to white), without which the delicate distance-picturing would be impossible. In summer the Blue Jay's perennially unchanged coloration is less closely fitted to its environment; but the bird is never conspicuous. The blue, seen in the leafy sylvan dimness, is usually soft and dull, and not sharply differentiated from the vinous ash-color of the breast and flanks; the white spots, as in all such cases, picture glints of sky, or lighter leaf-vistas; while the dark marks look like sticks and twigs and holes and shadows. (See Fig. 60.) Or again, when the clear, light blue of tail or wings gleams out with especial brightness, it may pass either for sky-shine on the leaves or for a bit of blue sky showing between them. Another boreal winter bird, the American Goshawk, in adult plumage, wears a beautiful combination of the color of bare twigs and deeply shadowed snow; and the nuthatches also have the same snow-shadow color on their backs.

Among the *Fringillidae*, the best example of a white-marked northern bird is the Snow Bunting (*Passerina nivalis*), common to both continents. Some of the redpoll linnets (*Acanthis*) have much white in their make-up (though mixed and blended rather than in clean spots). Some of the crossbills, and the pine grosbeaks, also have a share of it. But with most of the northern conivorous and bud-eating *fringilline* birds, *red* plays an important part, in the winter as well as in the summer plumage. For what are the chief colors of field and forest landscape in the northern winter? Three of them, black and white and blue, have already been named; what are the others? *Soft red*, gray (of tree trunks), and dusky green. Vinous ash-color ranging fairly into red is the hue of one large and ubiquitous element of these winter scenes, namely, the outer twigs of all the deciduous trees and bushes, covered with

buds. (See Plate VI again.) Except when a wet snowstorm or an icestorm has plastered and veiled these twigs, the average northern landscape in winter is full of great masses of soft, purplish red, reaching here and there a brighter tint. Golden brown, varying to red and purple, is also the color of the cones of spruce and pine and fir trees. It is among these pink and bronzy twigs and buds, seed tassels and cones, that the northern grosbeaks, linnets, and crossbills get their food, and the red or reddish colors worn by many of them are therefore in full accord with their environment. So it is also that the red spots on the heads of the males of northern woodpeckers are not discordant notes in their obliterative pattern.

Female crossbills and pine grosbeaks are olive-green, olive-yellow and gray—the colors of tree trunks and the foliage of evergreen conifers, and many of the cones themselves.

The coloration of some of these birds, notably the Red Crossbills, sometimes helps to produce a truly *mimetic* effect. In conformity with their acrobatic habits of topsy-turvy climbing and feeding, these crossbills have a very scant obliterative shading. In a full, unbroken light their solidity is therefore apt to show, and when they sit or cling on coniferous trees they often look much like cones, by virtue of their similar colors and not dissimilar shape.

Once more we must return to the subject of obliterative *white* markings on birds' upper sides. The birds that wear them may be grouped as follows: those that live high enough up in trees or bushes so that glints of sky and gleaming foliage-vistas are common factors of their background; those that live on the water or the borders of water, where *reflected* glints of sky are common; and, last but not least, those which live amid snow. Predatory birds that are mainly white all over, like many sea birds and the Snowy Owl, are, as we have shown, equipped for the greatest possible elusiveness when seen against the luminous sky by animals beneath them. The application of this principle among mammals we shall describe in a later chapter. Its bearing on the coloration of birds alone is large, far larger than one would at first suppose. It is involved, for instance, in such cases as those of the snow-

white herons, egrets and swans, whose whiteness tends to efface them against the sky, in the view of their aquatic prey and enemies, as no other color or system of colors could. Outside of the several classes above named, which means among ground birds and birds of the interior forest gloom, white markings are practically wanting, with the exception of those that belong purely and simply to obliterative shading, and the occasional white tail-spots, displayed chiefly in flight, which we shall consider in a later chapter.

The foregoing nineteen chapters together form an exposition, however fragmentary, of all the main laws of disguising-coloration as applied to birds, in as far as they have yet been discerned by my father. In truth, although we have disclosed much that is new, even in addition to the big general principles of *obliterative shading* and *picture-pattern*, yet the subject is no more than broached.

For several reasons we have seen fit to treat of birds in more detail than we shall attempt with other classes of animals. In the first place, birds are ahead of all other classes, with the doubtful exceptions of fishes and lepidopterous insects, in the elaborate variety and extreme development of their disguising-coloration. (The slender, simple hairs of mammals, for instance, are but a paltry medium for the building up of patterns, relative to the broad, flat and subtile feathers with which birds are covered.) In the second place we, personally, know more about birds than about any other animals. In the third and last place, the main principles of disguising-coloration are the same throughout the animal kingdom, and therefore if one describes them somewhat minutely in connection with one representative class, the other classes can be dismissed a great deal more briefly.

The next three chapters will deal with mammals.



SECRET

SECRET

SECRET

EXPLANATION OF PLATE VII

COTTONTAIL RABBIT.

Painted by Gerald H. Thayer. Background mainly by Emma B. Thayer and A. H. Thayer

CHAPTER XX

MAMMALS. GENERAL PRINCIPLES OF THEIR DISGUISED-COLORATION. FULL OBLITERATIVE SHADING ALMOST UNIVERSAL AMONG THEM. EXCEPTIONS CONSIDERED

ALMOST all mammals, from some of the biggest oceanic cetaceans to the smallest terrestrial quadrupeds, are equipped with a full oblitative shading of surface-colors. That is, they are darkest on the back and lightest on the belly, usually with connecting intermediate shades. *White* is by far the commonest color for the middles of their undersides, while the dark of the upper sides very often culminates in a black or dusky median line, a sort of painted 'ridge pole,' laid along the center of the back, over the tips of the dorsal vertebræ. With or without such extreme accentuation, complete oblitative shading characterizes most of the species of almost all the mammalian orders. This generalization applies to the great order *Marsupialia*, comprising the kangaroos, opossums, phalangers, the Tasmanian wolf, and many other forms; to the marine order *Cetacea* (whales, dolphins, porpoises, etc.); to the order *Chiroptera*, or bats; to the vast order *Rodentia*, including rats, mice, squirrels, beavers, hares, agoutis, porcupines, etc.; to the order *Insectivora* (hedgehogs, shrews, moles, etc.); to the order *Ungulata* (hoofed animals, among which we may here include, for convenience, the elephants and the hyrax, as well as the tapirs, rhinoceroses, and the hippopotami); to the great order *Carnivora* (containing the cats, from the lion to the lynx, the civets, mongooses, and hyenas; the canine beasts—dogs, wolves, jackals, foxes, etc.; the otters, weasels, raccoons, badgers, bears; the sea lions, walruses and seals); and to the order *Primates*, including lemurs, monkeys, apes and man. But in all the above-named orders, and notably in *Ungulata*, *Chiroptera*, and *Primates*, there are exceptions to the rule. These exceptions are

most significant, since, in almost every case, they accompany some important peculiarity in the animal's habits or physical characteristics. In the costumes of many bats, for instance, the counter shading is defective, or altogether lacking, the fur of the lower surface being almost or quite as dark as that of the upper. But this is in strictest keeping with their habits, for they are nocturnal and volant, flying swiftly, and for the most part feeding on the wing, like goatsuckers, while, unlike goatsuckers, they sleep by day in the pitchy darkness of deep caves and ruins, or in hollow trees, suspended by their hind claws, and hanging head downward, perpendicularly. Hence, it appears, Nature has been very little concerned with giving them disguising coloration. Their perpendicular sleeping-posture in itself precludes the possibility of their benefiting by the regulation obliterative shading while they are at rest. If they are to be counter shaded at all, it must be from tail to head, rather than from back to belly. Traces of such an aberrant shading exist on many species, in the shape of white or yellowish markings on the face,* and a brown paler than that of the rump and belly on the fore-back and fore-breast. This partial counter shading, as well as bats' prevailing earthy and rock-brown color, serves them in the cases where their roosts are more or less exposed to the daylight. Some kinds, indeed, habitually roost in the open air, under big tropical leaves, under the branches of trees, and on their trunks. The tree-trunk species while roosting are lighted as are scansorial birds, and for obliteration they would have to be counter shaded in the normal way,—as some of them are. But several of these open-air bats are developed for *mimicry* instead of obliteration. Thus a beautiful little South American species is formed, marked and colored to look like a woody knot or other excrescence on the underside of a mangrove branch, whereto it clings, by day; not hanging downward, but pressed close against the bark, holding on both with feet and finger-hooks. Usually several are found together, in a neatly distributed little group. Disturbed, they take wing all together, with a tiny, complaining twitter, and fly away like a troop of sand-

* See also Chapter XXII, p. 157.

pipers; alighting again, daintily and quickly, on the first new branch that suits them,—or sometimes wheeling and returning to their former perch,—and instantly they are changed back into lifeless knots.

When a normal obliterative shading does exist on bats, as is the case with a good many species, its main service is probably the making them additionally elusive in their crepuscular and nocturnal flights. The shading is usually rather slight, from deep brown to paler grayish, but it sometimes reaches dingy or even pure white.

There is no other important order of mammals in which obliterative shading and *disguising coloration* in general play so small a part. The comparatively few other beasts whose costumes are notable for their nonconformity with the predominant rules of obliterative coloration, may be grouped as follows: They are either strictly nocturnal (some of the smaller *carnivora*, and also some beasts which are large and fearless, but only semi-predaceous, e. g., many bears), or fossorial, living almost wholly underground (some edentates and moles), or arboreal, skulking (wont to take refuge in thick coverts and dense shade), and also acrobatic, often standing erect, and thus exposing their undersides to full light (e. g., some of the apes and monkeys), or protected by some extraordinary defensive equipment, so that they are in little or no danger from the attacks of predatory creatures (e. g., hedgehogs, porcupines, echidnas, pangolins, and some armadillos), or they enjoy a like security by virtue of their gigantic bigness, and, being herbivorous, have no need of obliterative coloration to aid them in securing their food (e. g., elephants, rhinoceroses, and hippopotami). Compared with the vast roll of the species equipped with full obliterative shading, the exceptions contained in these five classes are numerically insignificant. But they are important as bearing further weighty witness to the beautiful completeness of the correlation between animals' modes of life, defensive and offensive armaments, and disguising-coloration. The hedgehogs, porcupines, and echidnas (belonging respectively, in the sequence named, to the orders *Insectivora* and *Rodentia* and the order *Monotremata* of the strange subclass *Ornithodelphia*) are all

equipped with a thick coat of formidable spines, but have no oblitative shading, nor any other pronounced elements of concealing-coloration; whereas their closest relatives which lack the peculiar defensive armaments are all (if we set aside a few fossorial forms) obliteratedly colored to the full. The echidna's sole known ally, *Ornithorhynchus paradoxus*, the Duck-billed Platypus, has no spiny mantle, but its brown furry covering is obliteratedly shaded. So also with the coypou, beaver, and other rodents more or less closely allied to porcupines, and with all the spineless *Insectivora* akin to hedgehogs, with the possible exception of a few of those which live in dark tunnels underground, namely, moles and shrews. But the most strictly fossorial shrews, and even moles, must sometimes come out into the daylight, where they are exposed to the attacks of predaceous birds and beasts; and accordingly we find some degree of oblitative shading in the coats of almost all the species. There may be some kinds which are as dark on the belly as on the back; but not one of the most monochrome-looking species we have examined has proved to be so.

Among apes and monkeys, the want of pronounced counter shading is by no means uncommon, though it does not characterize the majority of species. This lack may be fully seen on the big anthropoid, semi-erect apes, the scrawny hair of whose breasts and bellies is as dark as that of their backs. But, thanks to their size and strength and ferocity, these great apes belong in part to the class of 'immune' beasts, while they also lack the need of oblitative coloration for offense which the truly rapacious animals have. The Orang-outan of Borneo is described as being the king of its native jungles, dreading only man; and we may well assume that the huge gorilla of central Africa enjoys equal privileges.

It might be supposed that whales were sufficiently protected by their colossal size and strength, and that the toothless kinds, which feed on the minute, lowly animal organisms that swarm in the ocean like dust motes in house air, would have no possible need of any kind of disguising-coloration. Yet almost all of them have a fully developed oblitative shad-

ing,* and almost all are subject to dangerous and deadly attacks from smaller marine animals,—such for instance as the Grampus or Killer (*Orca gladiator*).

Sea-cows or manatees, and dugongs (order *Sirenia*), those uncouth survivors of an ancient race of littoral-marine and fluviatile herbivorous mammals, are not pronouncedly equipped with oblitative shading. They are colored like grayish mud and dingy water, however, and tend to be palest underneath.

The predatory and semi-predatory land beasts which nearly or quite lack oblitative shading are few in number, and, as has been said, they are chiefly nocturnal.† Almost all belong to the group *Arctoidea*, or bearlike animals. Good examples are the black and brown bears of Europe and America, the Polar Bears (*Ursus maritimus*) the Wolverine (*Gulo luscus*), and several exclusively American beasts, the skunks (*Mephitis* and *Conepatus*), and the Fisher or Pennant's Martin (*Mustela pennanti*). But, though largely without counter shading, some of these animals are oblensively colored to a high degree. The Polar Bear, like the boreal foxes, hares, weasels and ptarmigans in their winter dress, is immaculate white, above and below; and, as has been explained in connection with ptarmigans (Chapter VII), this uniform whiteness is about the nearest approach to perfect oblitative coloration that an inhabitant of realms of glaring snow and ice can have, because there the monotonous, perfect whiteness makes counter shading inadmissible, since it would involve making the beast's top darker than the surrounding scene.‡ The shadowed and therefore too dark underside cannot be lightened, but neither must the fitly illuminated white back be darkened to match it, for then there would be a monochrome, complete (although flat-seeming) beast-form to silhouette against the background. The skunks, and in less degree the wolverine, are equipped with wonderfully efficient

* Those whales which prey, more or less, on forms that have both sight and power of locomotion, must be quite as much helped by oblitative coloration in their approach to such prey, as any of the beautifully counter shaded fishes that hunt in the same waters.—A. H. T.

† The slight counter shading of black nocturnal animals has apparently the exact degree to defeat the very small illumination of night.—A. H. T.

‡ See also p. 151.

ruptive patterns, of a peculiar sort, whose function will be explained in a later chapter. The other animals above named—brown and black bears and Pennant's Martin—are all nocturnal. The bears, furthermore, are too big and powerful to need defensive coloration; though, being partially rapacious, they do not wholly lack disguising-patterns. (See Chapter XXII.) Thus only the cases of the Fisher and a few other small carnivorous quadrupeds of like coloration remain in any degree anomalous, while the facts that such beasts are nocturnal, acrobatic, and deep-forest haunting, go far toward clearing up the difficulty.

The living members of that strange agglomeration of animals usually grouped by naturalists in the order *Edentata*, are almost all nocturnal, although they show otherwise great diversity of habits. Some are fossorial, some terrestrial; others semi-arboreal; others again, arboreal; and still others ultra-arboreal, being, alone among living mammals, practically incapable of any mode of progression except hanging themselves, belly-uppermost, along the undersides of tree-boughs and vines. Of course I refer now to the sloths, *Bradypodidae*. Their protective coloration is probably mimetic, in part at least, like that of certain bats, already mentioned. To be sure, they are often equipped with a slight *inverted* counter shading (from darker bellies to lighter backs, as in the case of many of the lepidopterous larvæ which feed and rest upside down); and their coloration often inclines also toward the 'ruptive,' based on bold, arbitrary patchiness. But these equipments are irregular and inconstant, and rarely or never would they appear to be of dominant importance. On the other hand, many travelers have commented on the *mimetic* function of sloths' queer, weedy-furred coats, aided by their shapelessness and sluggish habits; and such is very probably their chief protection. Hanging, lumplike, up among the complex, tangled forms of branch and leaf and vine and vegetable parasite, their rotundity perhaps revealed by the insufficiency of their counter shading, and at the same time obscured by their irregular, shaggy coats, they may well be hard to detect as animate forms. For they must look very much like masses of moss, withered air-plants, or other vegetable

débris, or like parts of moss-draped or ragged-barked boughs or trunks. So travelers have said, and in this case there seems to be no reason to question their interpretation. Sloths vary widely in color, but a rich olive-brown is perhaps the most characteristic tint. Sometimes they are almost *green*, owing to a growth of minute algæ on their fur; and this of course enhances the mimetic effect, allying them in the very ingredients of their superficial structure to the vegetable masses all about them. Again, they are sometimes rather brightly varied with patches of dark brown, blackish, dull orange and yellow, and even white; but these markings barely attain the rank of true 'ruptive' patterns. One marking, however, to which they are very prone, is extremely interesting and noteworthy. This is the blackish stripe or spot on the fore-back, surrounded by a rim of light color, varying from orange brown to white. Strangely enough, this marking is almost precisely duplicated on the head of a species of sphinx-moth larva (see Plate XV, Fig. T, Chapter XXV) and it there plays an important and unmistakable part in the imitation, beautifully achieved by the aspect of the entire caterpillar, of a pendant, curled-up, brown dead leaf. The larva hangs head downward, and its white-rimmed black spot pictures the shadowed hole at the tip of the pendant leaf-roll. There seems very little room for doubt that a like effect is achieved by the peculiar shoulder-spot of the sloth. Evidently, this simulates a shadowed orifice, with brightly contrasting outward rim, in the bottom of the vegetable mass mimicked by the entire beast. (See also page 157 of Chapter XXII, and Fig. 120.)

The armadillos (*Dasypodidæ*), another family of edentates, are terrestrial and fossorial, and almost hairless. But they are partially protected from their enemies by a hard, annulated shell, as well as by their prodigious digging-powers. Some species roll up into almost invulnerable balls, as do their African and Asiatic relatives, the armor-scaled pangolins (*Manidæ*). Both these families, besides being chiefly nocturnal, belong perhaps to the group of specially protected animals (although their armament is purely and passively defensive, like that of tortoises, and unlike that of porcupines), and their protective coloration accordingly is meager and irregular. Armadillos

are earth- and sand-colored above, and their broad, shelly roof, somewhat counter shaded, extends so far down over the sides as almost wholly to hide the shieldless and more or less hairy under parts, which, in conformity with the common law, are often decidedly paler in color. It is doubtful, though, whether the ventral paleness has in this case much significance beyond the lax and aborted pigmentation of a surface almost never exposed to view. But armadillos' heads and tails are always (?) counter shaded.

The *Myrmecophagidæ*, or American Ant-eaters, are all fully furred, and, despite their nocturnal habits, obliterated colored. Only three species are known, namely, the Great Ant-eater (*Myrmecophaga jubata*), the middle-sized Tamandua (*Tamandua tetradactyla*), and the Little Ant-eater (*Cylothurus didactylus*). *Myrmecophaga* is strictly terrestrial, but does not burrow; *Tamandua* is chiefly arboreal, and *Cylothurus* strictly so, being halfway to the sloths in habits and demeanor. The two larger kinds lack diurnal oblitative shading, but are equipped with powerful ruptive patterns of black, white and gray.* The exquisite, pale-brown furry coat of the little *Cylothurus* bears a rather faint oblitative shading, and a blackish 'secant' stripe along the underside.

The "Aard-vark" of South Africa (family *Orycteropodidæ*) represents the only other type of edentate that remains to be considered. It is strictly nocturnal, fossorial (living in deep burrows), and extremely timid and wary. Its body is scantily clothed with coarse brownish hair, and has in all probability the regular slight 'nocturnal' counter shading. (See the second footnote on page 123.)

I have already named the general rules which seem to govern these various breaks in the prevalence of full-blown oblitative coloration among mammals. To recapitulate, the exceptions occur, in the first place, among beasts that are habitually or very frequently hidden away from the light, either underground, in caves or hollow trees, in thick vegetation, or in the cloak of night. In the second place, they occur among beasts, mostly non-

* See Chapter XXII, p. 149.

predaceous, which are almost or quite immune from danger at the hands of their wild fellow-creatures, by virtue either of their great size and strength, or of a potent fixed defensive armament. In the third and last place, a few defenseless arboreal mammals are equipped for mimicry rather than obliteration.

It is, then, among unarmed, daylight-inhabiting mammals, and among the purely rapacious mammals, both of the plains and of the forest, that obliterative coloration, based on full and simple obliterative shading, reaches its highest and most uniform development. Many of the terrestrial beasts, particularly those of the open country, are equipped with full counter shading and 'ground'-color alone, almost or quite without markings. Such are lions, wolves, jackals, kangaroos, hares and rabbits; marmots, some gophers, and several smaller rodents and marsupials; as well as many of the big ungulates or ruminants, such as wild asses, some wild bovines, and many deer and antelopes. It has long been known that the animals of the desert are extremely alike in coloration—insects, reptiles, birds and mammals all sharing the same sandy brown. But coordinate with this fact is one hitherto ignored, namely, that the colors of these desert animals do as universally and unvaryingly constitute a perfect obliterative gradation of shades, from dark above to light below. As there is great monotony and uniformity in the animals' lighting and backgrounds, so is there sameness in their color-tints, in their all-essential obliterative shading, and in their scanty pattern,—when patterns occur, for they are often wholly wanting. Among the simply-colored mammals named above, the lion and the jackal may fairly be said to belong to the *desert* class. Most of the others are more characteristically inhabitants of grassy prairies; while some are partially sylvan. The Cottontail Rabbit (*Lepus floridanus transitionalis*) shown in Plate VII, at the head of this chapter, is a fair type of the fully counter-shaded, plain-colored terrestrial mammals.* These paintings of ours (rabbit, Ruffed Grouse, Copperhead Snake,

* More strictly, however, this hare is a semi-patterned, semi-sylvan beast, and one in whose normal backgrounds there is a good deal of variation.

caterpillars, etc.) are, we believe, the first ever published which rightly illustrate and in some respects do justice to the wonderful effects of obliterative coloration, based on the great law of *obliterative shading*. Many *photographs* of wild animals in nature (e. g., the ptarmigan shown in Fig. 41) illustrate the same thing with compelling force and beauty. Photography, indeed, is the great ally of those who would expound the laws of obliterative coloration; and it is destined—more swiftly now that the underlying principles of that beautiful phenomenon have been disclosed and analyzed—to effect a fundamental change in men's knowledge of the looks of animals in nature; and, by the same token, in the drawings and paintings men make of these wild animals. The world has had enough, or must soon have had enough, of pictures of birds and beasts with their light-and-shade falsified to make them show. Outdoor nature as it really is, in the matter of the marvelous and exquisite visual correlations between animal and environment, offers to art, in this late age, an almost boundless virgin field.

Figs. 84-89 and 93-94 are all photographs from live mammals, either in nature or captivity. Fig. 86 shows a tame hare upside down against a normal background. (See also the photographed flat hides of mammals shown in Figs. 11, 12, and 13 of Chapter II.)

Mammals, totally unlike birds, butterflies, and even fishes and reptiles, are almost wholly devoid of really gaudy surface-colors. In some few cases, mammalian fur reaches or nearly reaches the standard of pure color in the direction of yellow, green, and possibly orange; but its normal and usual range of tint is through all the grades of neutral, from black to white, and through the entire scale of browns and grays, from vivid rust-color to cold bluish gray. When clear, gaudy color does occur on mammals, it is usually in the naked skin, as on the faces and rumps of certain monkeys and baboons. Now whether, as may well be the case, mammalian hairs are, as compared with the feathers of birds, the scales of butterflies, and the skin and scales of fishes, structurally incapable of producing brilliant colors, there is yet a sufficient ulterior reason why we should expect to find mammals brown and gray,

FIG. 84. Wild Cottontail Rabbit (*Lepus floridanus transitionalis*) in position. 'Obliterated' by counter-shading and faint ground-picturing pattern.

Photographed from life, outdoors. Captive rabbit.



FIG. 85. Domestic hare. Obliterative shading, etc. Photographed from life.



FIG. 86. Domestic hare laid on its back, outdoors, so that the obliterative shading is reversed. Photographed from life.





or at least much less brightly colored than birds, etc. The fact that they are so becomes in fact one more strong link in the chain of evidence in proof of the universal and paramount importance of concealing-coloration. Mammals (we will exclude the aberrant forms, as the bats—winged, nocturnal, and cavern-haunting—and the marine types) are characteristically flightless, and hence, in a great measure, tied to earth. In the forest, the outermost skyward excursions of the most arboreal species rarely or never take them into the gay regions inhabited by the more brilliant birds and butterflies. For these are masters of that unstable element, the air, and can go whither they please above as well as upon and through the ground and the forest. Hovering, flitting, perching lightly, always ready to resort to their wings in an instant if the perch should fail them, even many of the heavier members of this gifted class—even many of the birds, in short—are wont to pass most of their time in the brilliantly lighted outermost border of the forest, among the very tips of the slenderest twigs, where most of the fruits and flowers grow, but whither even the most agile climbers of all the wingless mammals dare not venture. Metaphorically speaking, birds and butterflies are creatures of the grave and ponderous globe's exterior efflorescence, of the colored foam at the outermost edge of things, of the borderland between earth and sky; while mammals, man included, are citizens of the sober underworld. Plodding, earth-bound things, they walk upon the solid ground, and drive their tunnels in the darkness under it; while some of them ascend its skyward excrescences, the trees; but high as they may go they are still the creatures of the 'underworld,' and the bright realm of butterflies and birds is still as a rule above them. By their life-laws, they are forever associated in close contiguity with things brown and gray and black;—mud, sand, the dead leaves and twigs of the forest floor, rocks and pebbles, tree trunks and branches—and the black holes and shadows among all these things. Some few of the most arboreal kinds live in the realm of preponderant sylvan *greenness* (see p. 108 of Chapter XIX), and several of these (small monkeys, etc.) have olive-green or even clear green and sometimes yellow fur. But as no wingless

mammals attain, except in rare chance moments, to the bright and efflorescent 'borderland,' the headquarters of the brilliant butterflies and birds, so are there practically *no* really *gaudy* mammals. Furthermore, it will be found, in almost every case, that the birds most closely akin, in ways of life and local habitat, to some dull-colored mammal, are themselves dull-colored; for birds are distributed ubiquitously, from their own special realm to the mammals' stronghold, the solid ground below. (See p. 107 of Chapter XIX.) Even outside the forest, the characteristic difference between the two classes, in habits and in accompanying coloration, is maintained. Wherever there is vegetation of any sort, down to lowly herbage, there it is the general wont of *birds* to feed and fly and climb on *top* of it, in the light, and amid bright colors, and the general wont of *mammals* to feed and crawl about *below* it, amid shadows and dull colors. This generalization applies even to semi-aquatic birds and beasts. Wood Ducks swim high, and often sit on trees; kingfishers sit on stumps and branches above the water; Purple Gallinules walk about, erect, on lily pads; and all these birds are marked with rich or brilliant water-colors. Otters, muskrats, beavers, capybaras, and other semi-aquatic mammals, swim either under water or almost submerged, showing only a low line of back and head. When they are out of the water they are always close to terra firma—on the muddy shores, in holes, or running about *under* the bushes and weeds and tree-roots; and no one of these beasts is brightly colored. But here again we find that the bird tribe invades the mammal tribe's proper realm, and shares its system of dingy colors, though the mammal tribe cannot reciprocate. Thus there are rails and other marsh birds that live like skulking quadrupeds, *on the ground below* the reeds and bushes, and like them also they lack brilliant colors.* To sum up: on the bare fields and deserts, in the dusky forest shades, and below the taller vegetation in the marshes, there are 'mammal-colored' birds; but nowhere are there 'bird-colored' mammals. (A statement essentially correct, though for absolute accuracy it would need some qualifying.)

* Except on their beaks, legs, etc., in the breeding season.

Equally in keeping with mammals' lack of gay colors and minutely elaborate patterns is the fact that the great majority of them are nocturnal, hiding by day in hollow trees and holes in the ground. Nevertheless, in addition to a complete general adequacy, based, for the most part, on full and perfect counter shading, mammalian concealing-costume presents many beautiful types of generalized obliterative picture-pattern. Some of these are the subjects of our next two chapters.

CHAPTER XXI

MAMMALS, CONTINUED. MARKINGS OF COUNTER-SHADED MAMMALS. THE MAIN TYPES OF THEIR OBLITERATIVE PICTURE PATTERNS

WHILE the beasts of the open land, such as lions, kangaroos, and many hares, are notable for their almost complete lack of markings, although obliteratively shaded and tinted to a high degree, the costumes of many of the forest-haunting and tree-climbing mammals are characterized by strong and beautiful picture-patterns. Among these, there is perhaps none more potent and remarkable than the checkered sun-fleck and leaf-shadow pattern, worn by leopards, jaguars, ocelots, giraffes, and other sylvan mammals, and even by some snakes—e. g., several of the great constrictors. It varies, of course, from species to species; but its essential character is always the same, and it is always the handmaid of complete oblitative shading. Who has not noticed, in the forest, the flickering play of circular (or broken) sun-flecks and branched, encompassing leaf shadows? There is no more typical and familiar sylvan sight. Where the forest's crown is not too dense, this beautiful tremulous pattern marks all the brown ground where the matted dead leaves lie, and even checkers the sides and bases of some of the upright trunks, and the tops and sides of the naked lower branches. In deeper woods, where the leafage is extremely full and crowded, little or none of this sun-engendered pattern penetrates to the ground, which then is cloaked in uniform and quiet shade. But somewhere between the dim brown ground and the green and gaudy-flashing tree-tops there is always a large intermediate tract, where, amid trunks and spreading branches, twigs and scattered leaves, the checkered pattern reigns supreme, dancing softly on the upper side of everything; and, helped by the varied glinting of the lower leaves themselves, it transmutes



FIG. 87. GRAP. XXI. Photograph of a captive Jaguar, with a background, as of forest leaves in light and shadow, painted around him. The Jaguar is the same as that published by C. W. Beebe in his "The Bird," and is here used with the kind permission of Mr. Beebe, E. R. Sanborn and Henry Holt & Co.

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all that portion of the forest into a shimmering disorder of small, shattered lights and shadows, in which the actual solid details seem inextricably merged. To witness this effect in full, one must of course look at the scene from a point somewhat above it; but the pattern one sees in looking *upward* through the forest leaves, where they are not so crowded as quite to hide the sky, is of much the same nature. Indeed, this latter sort is in some respects more like that worn by leopards, etc., than is the true sun-fleck pattern. For the predominant effect of the leopard's pattern, and of that made by leaves against the sky, is of symmetrical dark marks on an irregular light ground—proportions which the sun-fleck pattern inverts, except where it is exceedingly profuse. But what we see on the hides of these checkered sylvan beasts is really an apt and efficient generalization of this entire class of forest-patterns, including the much-used *picturing of holes*, done all in brown and black and golden forest-interior color.

Among the species named at the beginning of this chapter, all but the giraffe are arboreal—that is, *tree-climbing*—while the giraffe's great height keeps him also in the region of frequent sun-flecks, as he feeds among low trees and lofty bushes. But the 'checkered' pattern in general is so characteristic of all lights and shadows in the woods, that, whether the beast so marked have for a background the variegated middles of trees, an under view of their leafy tops against the sky, or the flat brown forest floor, he will almost always be adequately 'obliterated.' *Everywhere, under leafy trees*, exist these simple, elemental patterns, whose likeness on the hides of beasts men deem so beautiful.

A leopard or a jaguar stretched out on a lofty branch, lying in wait for monkeys, his deceitfully counter-shaded and spotted coat dappled into still further indistinctness by the very shadows and sun-spots it counterfeits, must be about the most insidiously inconspicuous of hunters. (See Fig. 87.) But not all leopards and jaguars have this brilliantly obliterative forest-coloration. Both species are rather prone to melanism, being sometimes almost wholly black, with scant traces either of counter shading or pattern. It would

be very interesting to discover whether or not the dusky individuals tend to be more strictly nocturnal in their habits; for they are certainly less well equipped for stalking and ambushing their prey in the broad daylight.

The giraffe's or camelopard's pattern is simpler than the leopard's, consisting of but two well-marked color tones instead of three. The dark spots are rich brown instead of black, representing, as it were, a consolidation of the leopard's two darker tones. Giraffes, however, are subject to a good deal of individual (?), sexual, and geographical variation in the color and shade of the spots, as well as of the branching, irregular light bands by which the spots are divided. But their pattern always maintains its potency for obliteration, particularly in (low) woods, amid shimmering sunshine and leaf shadows, and more distant leaves and leaf-clusters and small branches silhouetting against the sky. In this, their foremost and special obliterative function, the mammalian and reptilian checker-patterns, coöperant with a full obliterative shading, must be reckoned among patterns which picture the background, like those much more elaborate and minute of many birds. (See Chapters IV, V, VI, VII, etc.) But they have also, in common with almost all other patterns, and notably all that are sharp and bold, a simple, inherent obliterative effect. The sharp spots thickly scattered over the leopard's coat, and the eccentric patchwork-marks worn by his huge, stilt-legged, ruminant namesake, are in themselves a kind of mask or veil for the solid animal forms beneath them. Their bright, irregular and inorganic pattern takes from the visibility of their wearers' contours, and goes far toward effacing all the minor details and chance-shown lesser lights and shadows of the beasts' solid but obliteratively shaded forms. A glance at Figs. 1, 14, and 87 will tell the reader more about this than many words. In the case of such an animal as the Jaguar shown in Fig. 87, the perfection of the obliterative shading, denying as it does the presence of a solid body underneath the spots, tends to make these seem to belong to the background, even if that is not elsewhere spotted; and thus the simple 'retrocessive' obliteration is in part maintained. Nevertheless, a highly spotted (or otherwise closely marked)





FIG. 88. Zebras at a drinking place. At the right is a patch of vegetation amid and against which they must be extraordinarily inconspicuous.

Flashlight photograph from nature by C. G. Schilling. Here reproduced with the permission of Herr Schillings and his publishers.

animal, even though perfectly counter shaded, is of course out of place and more or less clearly visible against a perfectly plain background, because his figure *silhouettes* against the monochrome scene by virtue of its continuous pattern. This fact, or the converse of it, the noticeableness of a monochrome object against a patterned background, has already been demonstrated (Chapter III, Figs. 15-16). But few natural backgrounds, even in the open lands, are entirely immaculate; and hence some degree of flecking is nearly always advantageous, though often not essential, in an animal's obliterative coloration.

There is a complete gradation of types between the leopards, ocelots, giraffes and boas, with their rich, specialized, forest-picturing 'checker' patterns, through such more weakly and ambiguously spotted beasts as the Ounce and Serval—the one apparently modified for snow and the other for the more open country—to the immaculate lions and (certain) antelopes. In the same way another beautiful and important type of obliterative pattern, namely, *transverse striping*, grades from its extreme development on the zebras and tigers, through various lessened and modified forms, to its last and slightest appearance on such animals as Livingstone's Eland, and other antelopes, from which it is but a step to the stripeless ruminants and carnivores of the open ground. Among all the bolder obliterative patterns worn by mammals, that of the zebras (*Equus zebra* and *E. burchelli*) probably bears away the palm for potency and beauty.* The wonderful photographs of live wild zebras (Figs. 88 and 89), here reproduced with the permission of their author, Herr Schillings, and his publishers, clearly illustrate one main phase of the obliterative force of these beasts' patterns. The brilliant cross-bands 'cut their wearers all to pieces,' and look exactly like the stripings of the lighted reeds across their shadowed background. To aid in a fuller

* Kipling, in one of his "Just So Stories," "How the Leopard Got His Spots," which we have just read for the first time, gives a most keen and appreciative description of the marvelous concealing-power of the costumes of the zebra, leopard, and giraffe. He does not *analyze* the magic of these patterns, for he says nothing of the principle which underprops it, *counter shading*; but the *magic in operation* he has perceived and told about as no other man we know of has.

analysis of this effect, and kindred ones, we give also some diagrams—some *imitation* zebra pictures. Figs. 90, 91, and 92 are photographs of a zebra-shaped model cut out of flat cardboard, and placed amid straws and imitation reeds or grasses, artificially arranged. In Fig. 90 the grasses relieve light against a dark background (as in the real zebra photographs by Schillings), and the zebra-to-be—now a wild ass (!)—is tinted uniformly with a shade intermediate between background and grasses. Being actually flat, as the real live zebra is made to *appear* by its full obliterative shading, this monochrome model is not revealed by any look of solidity; yet it is visible and recognizable, because its stripeless surface, with its organic and peculiar outline, interrupts and relieves against the striped pattern behind it. In Fig. 91, the same model, against the same background, has been converted into a zebra, by the application of the proper bands or stripes,—and notice the result! The cardboard figure, standing almost where it stood before, and in exactly the same lighting, has practically disappeared from view. Its sharp bands carry the striate pattern of straws and dusky background across its every part, thereby obliterating it almost completely. (Schillings's zebras didn't happen to have a fully and evenly striped background at the moment when he photographed them,* and therefore the effect of actual background-*matching* is only fragmentarily shown by his pictures.) Fig. 92 shows the same thing over again, with the difference that the striped background is made by imitation reeds relieving *dark* against white paper; the reverse of the former case. These two sorts of background are almost equally well suited to the zebra-pattern, as our pictures show. Both are imitated from nature, the one corresponding to a landscape with brightly lighted grasses, reeds, or other tall and slender plants, relieving against dark ground or water, or against the shadowed interior mass of their own kind (see Schillings's pictures, Figs. 88 and 89), and the other to a landscape in which such plants in somewhat open array relieve darkly against bright sky or water. Again, the *shadows* of these tall and linear plants—or even of plants more treelike and branching—cast

* (not to speak of the extreme abnormality of the lighting).—A. H. T.



Artificial ass and zebra, looked at from the low view-point of an ambushed lion, showing the effacing-effect of the stripes in actual operation. (Study this picture from a distance.)
Substituted for the Schilling's photograph, Fig. 89, since the book was printed.



upon the sandy or otherwise pale-colored ground in sun- or moon-light, make a pattern very much like the zebra's.* So also with the *reflections* of such plants on quiet water. Scenes like these are doubtless typical of all the country in which zebras live. For however arid and barren, through much of the year, are the hills and plains and plateaux over which the Mountain Zebra ranges, or used to range, they are yet clothed with tall plants of many sorts, including rank grasses, which no doubt stand erect for months after they are withered by drought. Furthermore, all beasts must have water, and so the zebras of the dry plains must needs make frequent visits to the nearest living sloughs and rivers. There, by the water's edge, tall reeds and grasses almost always flourish—often in broad beds of marshy verdure—and there, where all beasts meet to drink, is the great place of danger for the ruminants, and all on whom the lion preys. In the open land, they can often detect their enemy afar off, and depend on their fleetness for escape; but when they are down in the river bed, among the reeds, he may approach unseen and leap among them without any warning. It is probably at these drinking-places that the zebra's pattern is most beneficently potent. From far or near, the watching eye of the hunter † (bestial or human) is likely to see nothing, or nothing but reed-stripes, where it might otherwise detect the contour of a zebra. The extraordinary brilliancy of these stripes, which for the most part are clear black and white in sharpest contrast (much dimmed, of course, by shadows, when the beast stands amidst vegetation), makes them effectively obliterative at a great distance, where weaker markings would merge and vanish, thereby allowing their wearer's contour to become apparent. Nor is this brilliance detrimental to the effect in a near view,—the stripes, as Schill-

* One may satisfy oneself of this even in the snowy winter woods of northern Europe or America, where, in the slanting light of sun or moon, the shadows of naked trees lie thickly scattered on the pure-white ground. Those of the trunks are mostly parallel, and perspective gathers them into narrowly banded patterns, while those of the branches, though much more irregular, also tend to form patterns of this type.

† However largely lions and other rapacious mammals hunt by *scent*, it is not scent, but sight alone, that can serve them when they are *down wind* of their quarry; and sight alone must guide their ultimate killing dash and spring.—A. H. T.

ings's pictures testify, still play their true obliterative part, 'cutting the beast to pieces' and wedding him to the strong and manifold striations of the vegetation all about him. Indeed, a pattern so multiplexly and fundamentally 'secant' 'cuts its wearer's aspect to pieces' in almost every view, only failing to be purely obliterative when the beast is seen against a *perfectly plain background*. Against *any appropriate* background, on the other hand—as one of reeds and grasses, or even bare-limbed bushes and low trees, or sand streaked with the shadows of any of these plants, or quiet water striped with their reflections—its obliterative effect must be almost perfect. A slightly different phase of this pattern's use is that which comes into play when the zebra stands amid lower reeds (or other plants) with its upper parts relieving against the sky, or against dim, distant ground, or water. Its body then looks like the upward continuation of the grasses or reeds encompassing its legs;—the dark stripes continuing the reeds upward, and the light stripes between them continuing the sky or other pale background downward, so that the beast's contour, which otherwise could scarcely fail to show in this position, is still 'cut up' and concealed. This 'letting in,' or 'drawing down,' of sky into an animal's silhouette is a regular and frequent factor of obliterative coloration, occurring in many forms, in many classes of animals, but most notably among birds and mammals. The reader will hear more of it in the next chapter.

Burchell's Zebra, the species photographed by Schillings,* is much like the now almost extinct Mountain Zebra in general coloration and pattern, but its light markings are more yellowish, and the secant bands are fewer and broader and somewhat differently distributed. On the whole, the Mountain Zebra has the more highly wrought obliterative costume, and that of Burchell's is one step down toward the much slighter pattern of the Quagga (*Equus quagga*). This beast, which has lately been exterminated, was banded only on the fore part of the body, and there irregularly, with light and dark brown. The transverse leg- and flank-bars of both zebras (but particularly

* Strictly speaking, his beasts belong to subspecifically differentiated races of *burchelli*.



FIG. 90. Cardboard 'zebra' without stripes, against light straws as in FIG. 91.
Photograph, retouched.



FIG. 91. Cardboard zebra among straws 'relieving' light, like reeds or grasses against dark ground.
Photograph, retouched.



FIG. 92. Cardboard zebra among imitation reeds 'relieving' dark, as against the sky.
Photograph, retouched.

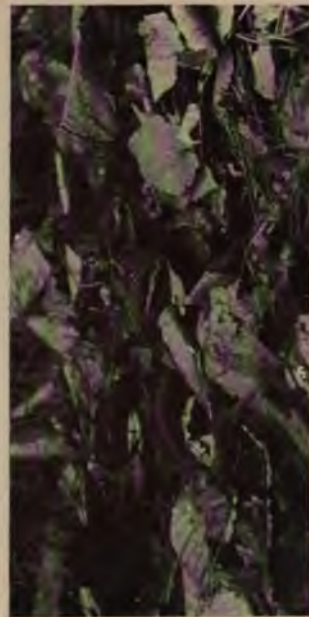


FIG. 93. Chipmunk (*Tamias striatus*) among dead leaves, its stripes picturing sticks or leaf-edges and shadows. (These picture-patterns are, of course, based on perfect obliterative shading.)
Photographed from life, outdoors. (Captive chipmunk.)

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of the mountain kind), opposed to the more or less vertical body-bands, call for a word of comment. They are an example of 'secantly' oblitative marking as distinguished from pure and simple picture-pattern. Striped up and down, the legs would continue the body's depiction of standing reeds or tufts of grass, but they might also look like an animal's legs, for their true form and general trend would be obscured but little. The legs, like the body, must be cut *crosswise* by secant stripes, if they are to be fitly disguised. As was explained in Chapter XIII, such stripes achieve their full effect only when aided by corresponding background-markings. Though the zebra walks amid upright grasses, etc., *crisscrossing* and *horizontal* stems and blades are of course common enough in his haunts to yield the required amount of cooperation to his essentially 'secant' horizontal leg-bands. When the zebra is lying down, with legs outstretched, these transverse leg-bands have of course a *vertical* direction, like the body-markings. This, perhaps, is the position which best favors, in the aggregate, the proper working of his oblitative pattern. Still another detail of these wonderful harlequins' costumes which demands especial notice is the delicately striped head-pattern. This is worn in almost equally high development by both zebras. It is by every test a picture-pattern. For, just as in the case of the picture-patterned birds (Chapter III, p. 32), this head-pattern of the zebra's is much smaller and finer than that of the body, as if to match a striped background decidedly reduced by distance—just such a one as the head, being the highest part, must normally have in relation to the lower body. Considering birds alone, a skeptic might suggest that the smallness of the head-pattern may be merely the simple physical consequence of the smallness of the head-*feathers*; but such a theory would break down when confronted with the fact that there is a like proportion in the sizes of pattern between the heads and bodies of oblensively colored hairy mammals. A single feather often contributes the whole of an important spot, or even several spots, to the general pattern, so that small feathers might mean small markings; but patterns made with hair are very different. It takes many hundred crowded hairs to make a

small detail of such a pattern as the zebra's, each separate hair contributing but a tiny share to the effect, so that the markings might be disposed quite arbitrarily on the beast's coat, as far as the mere form and character of their component parts is concerned.

Near akin to the zebra-pattern is that worn by tigers. But the tiger's black stripes are narrower, further apart, and more broken and irregular, while its ground-color is tawny or deep golden brown instead of white or pale buff. The main oblitative principles, however, are alike in both. The tiger's coat is obliterated to minute perfection—darkest along the ridge of the back, lightest on the throat and belly, with intermediate shades for intermediate regions and smaller details of rotundity. His general color is that of the interiors of bushy thickets, reed-beds, the underwood of the loftier jungle, and all brown, half-shaded coverts; while his stripes picture vertical stems and slender trunks in shadow, and also the sun- or moon-engendered shadows that such plants cast upon the ground in opener places. As with the zebra, however, his pattern is essentially and intrinsically 'se-cant' and oblitative, and nothing short of a perfectly plain background can neutralize its power. He is a beast who hunts his prey by stalking, often in full daylight; accordingly, his huge form has been 'blotted out' by counter shading; he is likewise a beast who hunts in and among bushy and grassy thickets, full of upright 'stripes' of vegetation, and accordingly he bears a system of generalized dusky stripes upon his brown, obliterated-shaded coat. The terrible inconspicuousness of the tiger in his native jungles has long been a famous fact, and no evidence on that score need here be cited. Suffice it to say that this inconspicuousness is due *primarily* to the beast's oblitative shading, and secondarily to his stripes and his tan-color, which have hitherto alone been held responsible, in the opinion of men. Turn a dead tiger or his stuffed skin upside down in a normal outdoor lighting, and, arrange him as you will against fitting backgrounds, he will be *not dim and illusive, but conspicuous*, because of his now inverted oblitative shading.

The tiger has a vast geographical range, extending from the humid jungles of Sumatra to the snowy mountains and plateaux of northern China and Siberia; and like most widely distributed beasts and birds, it has developed several regional races, differing mainly in superficial characters. As the Ounce or Snow Leopard differs from the true leopard type in coloration, so, to some degree, does the North Asian mountain tiger differ from the jungle tigers of the South. Its ground-color is paler—sometimes almost ashen-white—and the stripes are scantier and more broken. These differences correspond to those of the beasts' habitats—the northern tiger living amid rocks and sometimes snow, in regions where tall upright stalks of vegetation are comparatively uncharacteristic features of the landscape. Thus, in almost all cases, can one trace an apparent *raison d'être* of color- and pattern-differences among nearly allied animals. There are a few cases more baffling, but the seeming obscurity of these doubtless depends on our ignorance of many fine points of difference or affinity in the beasts' life histories. Some animals, for instance, seem to have a superlatively elaborate oblitative equipment, while other closely allied species with nearly similar habits, living in the same regions, are patterned much more simply. This is the case with the two 'harlequin' zebras and their relative the scantily half-striped Quagga. As the Quagga was banded only on its *fore* quarters, so the Thylacine, or Tasmanian Wolf, is banded only on its *hind*. Another Australian marsupial, the little ant-eating *Myrmecobius fasciatus*, is brilliantly zebra-banded from its shoulders to its tail. But among all the beasts that bear more fragmentary vertically-secant patterns, the African antelopes are probably the most noteworthy. Many antelopes of that continent, indeed, are almost or quite unmarked—smooth brown or gray, oblensively shaded, with the regulation white or very pale-tinted bellies. But others are brightly, if somewhat scantily, striped, and sometimes spotted, on the back and sides and legs, with white and black—especially white. The most amply and regularly banded of these is the Koodoo (*Strepsiceros kudu*), which has many vertical white stripes on a dark-brown ground. This beast, as its markings would suggest, is an inhab-

itant of regions with rather ample vegetation—such as reedy river-margins. Indeed, its average environment and its disguising coloration are very much like the zebra's. In the same class of 'secantly' striped antelopian costumes is that of Livingstone's Eland, mentioned a few pages back. This magnificent great antelope has black marks on its fore legs, while its brown back and sides, otherwise immaculate, are marked with five narrow vertical lines of gleaming white, extending from the ridge of the back about two thirds of the way to the middle line of the belly. These stripes, like those so much more numerous and bold worn by the zebras—and even the Koodoo—are secantly obliterative. They bring down, as it were, narrow slips of sky into the beast's smooth contour, when he stands upon an eminence and silhouettes against the distance—and thus they 'cut the contour up' and tend to obliterate it. Again, under other conditions, these stripes carry the aspect of stray gleaming grasses or reed-stems upward across the eland's earth-colored, obliteratively shaded body. In all such views, and in others where the 'picturing' effect is less pronounced, these stripes are definitely obliterative, always tending to 'cut up' the aspect of the eland's form. The Common Eland wholly lacks these markings, as do many other African antelopes; and here we have another case of notable costume-differences among animals with nearly or seemingly quite the same habits and environments. No doubt, however, there are really equivalent differences in the beasts' average surroundings, and in their behavior, even though these have not yet been noticed by man. Thus Livingstone's Eland may have a greater propensity to stand still in time of danger, or may spend more time amidst tall grasses and reeds, than those of its near relatives that lack the secant stripes. In the same way the more profuse and variegated white markings of the Harnessed Antelopes, containing an admixture of white *spots*, are probably an indication that these beasts spend an unusually large proportion of their time in and about wet swamps and river borders, where flecks of water-shine—glints and stripes of sky-reflection—are common features of the scene. The small, irregularly circular white spots on the common Harnessed Antelope are indeed almost exactly like those

which are prominent in the patterns of certain semi-aquatic mammals; and they also correspond closely to the water-shine flecks of aquatic and swamp-haunting birds. (See Chapter XI, p. 61.) Two beasts of this type are the African Water Chevrotain (*Hyomoschus aquaticus*) and the South American Lape or Paca (*Cælogenys paca*). Though belonging to different orders (the Chevrotain being a ruminant and the Lape a rodent) these two animals are much alike in general habits, while in pattern they are almost identical. The ground color of the Chevrotain's coat is richer and redder brown than that of the Paca's, but it bears almost exactly the same system of white flecks—irregular white spots, in places almost or quite confluent, and forming longitudinal chains or stripes. If these two beasts lived in the same swamps, naturalists would very likely consider their superficial likeness a case of 'mimicry.' But since they live on different continents, there is no disputing the statement that they are independently equipped with water-shine patterns of the same simple, generalized type, which occurs the world over both on mammals and on birds.

As the zebras' bands are *vertically* 'secant,' so lengthwise stripes, of which we see the first signs on the Harnessed Antelopes and the two water-beasts just described, are *longitudinally* secant, like those of certain gallinaceous birds and sparrows, etc. (Chapter XIII, p. 78). On mammals, this truly *striped* pattern appears in many forms and many degrees of elaboration, being sometimes merely *secant*, with no very particular suggestion of background-picturing, and sometimes highly 'pictorial.' Many of the North American Ground Squirrels, and Spermophiles (*Tamias* and *Spermophilus*), are marked with bright, longitudinally striate patterns of black and brown alone. The Common Chipmunk (*Tamias striatus*), of eastern North America, has few but highly developed markings, its one composite side-stripe being formed by a central whitish stripe inclosed within two black ones. (See Fig. 93.) Painted thus boldly on the little beast's obliteratively shaded, beautifully dim and flat-looking, honey-brown body, these markings much enhance its elusiveness by distracting the beholder's eye from any faint mod-

ulations of the creature's form which might otherwise be apparent; while each of these stripes looks in itself like a bright stick, twig, grass-blade, leaf-edge, or weed stem standing out above a shadow—either its own or a more general background-shadow, which shows on either side of it. Or again, this marking suggests a shiny, cylindrical stick or stem, with its central streak of highlight, and the bordering shadows on itself, caused by its own curvature. Still another detail of ground-scene which these chipmunk-stripes suggest is the pattern made by sunlight falling between parallel twigs or stems—narrow, shadow-bordered sun-streaks on the earth or leaves or stones. They are, in short, generalized but most efficient picture-patterns. The western Four-striped Ground Squirrel (*Tamias quadrivittatus*) is colored and marked much like the eastern Chipmunk, but its stripes, besides being more in number, are narrower, and, as picture-patterns, perhaps even more generalized. Notable among the several other modifications of this pattern to be found on North American mammals is that worn by the beautiful Thirteen-lined Ground Squirrel (*Spermophilus tridecemlineatus*). The black intervals between its many light-colored secant stripes are traversed by lengthwise chains of bright spots, like slender flower-spikes or little leaves over shadow. On some spermophiles (as *S. grammurus douglassii*), the secant pattern is reduced to a single broad black stripe along the middle of the back—an exaggeration of the dusky 'ridgepole' mentioned at the beginning of Chapter XX.

An illustration of the obscurer type of generalized *flecky* background pattern on mammals was given in Plate VII. It is a type extremely prevalent among terrestrial mammals. Indeed, if we include all its offshoots, such as the system of regular, scale-like bright flecks on a dark ground, worn for instance by certain spermophiles, it is the commonest as it is the obscurest kind of mammalian pattern. It is worn by many terrestrial rodents, etc., of the open ground—e. g., hares, gophers, lemmings, spermophiles—and, variously modified, by many terrestrial forest mammals. Simplified to a close, bark-like grizzling, it is characteristic of many arboreal beasts, such as squirrels and some of the marmosets and lemurs. With very few exceptions,

patterns of this kind are accompanied by—or better, they are the accompaniment of—complete and perfectly efficient oblitative shading. They grade, however, into the more bold and special types of pattern. Thus the obscurely flecky pattern of some lynxes shows here and there a spot which is halfway to the clean, sharp “rosettes” of leopards and jaguars. On the other hand, the flecky pattern grades downward into nothing, so to speak, and many mammals are almost or quite without markings, though perfectly counter shaded, and colored brown or gray like the ground or tree trunks. Such are many rats, mice, shrews, etc., and, among large mammals, lions, pumas, wild asses, and many horned ruminants.

An interesting parallel between the disguising-equipments of mammals and those of birds is furnished by the obliterated young of many species in which the adults are without markings. The special oblitative costumes of young gulls and other birds was described in Chapter XIV. Among mammals, some of the deer and wild swine are notable examples. The adults are obliterated but unspotted, while the fawns and little wild pigs are super-equipped with an oblitative pattern of light spots, which lasts through their baby-time of comparative sluggishness and helplessness. These spots belong to the class of generalized flecky background-patterns, inclining on some fawns to sun-fleck and leaf-shadow picturing, and on pigs to water-shine picturing. Some deer—for instance the European Fallow and the Indian Axis Deer—retain the youthful pattern of oblitative flecks through life. This simple, spotty pattern is connected by various intermediates with other types of cervine and antelope marking—such as the vertical bands of the Koodoo, the bands, stripes and spots of the Harnessed Antelopes, the softly ‘ruptive’ and background-picturing broad patches of whitish on light brown worn by the American Prongbuck (*Antilocapra americana*), etc. Indeed, with mammals as with birds, the special types of marking are all more or less smoothly connected one with another by intermediate types—worn, for the most part, by beasts which are evidently intermediate in habits also. But we have now mentioned and briefly analyzed the workings of the main

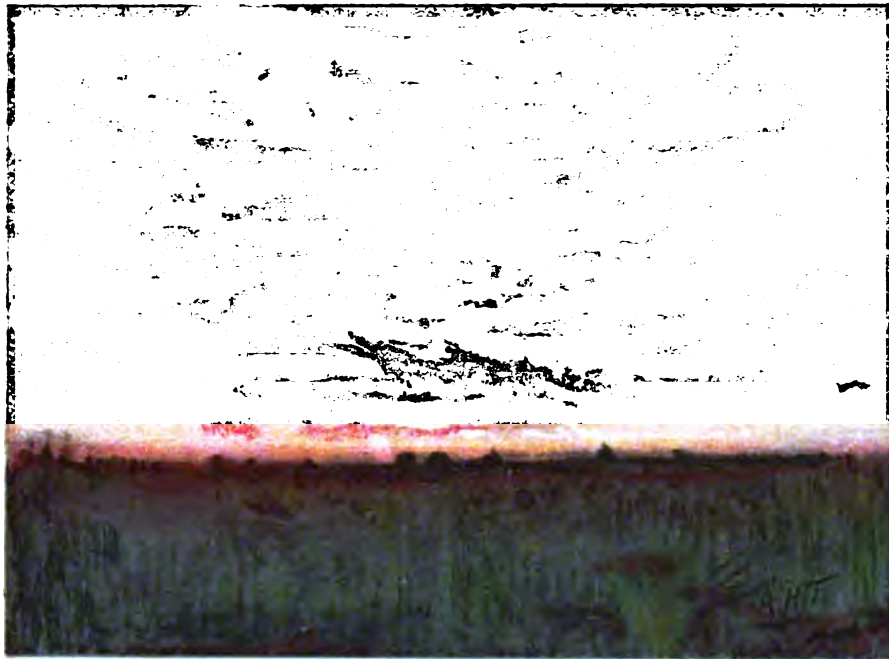
central types of mammalian picture-pattern coöperant with counter shading, as far as they are known to us. Wittingly and unwittingly, we have passed by a multitude of minor variations and adaptations, and may even have missed some types of foremost importance.

The next chapter deals mainly with the patterns of mammals which lack diurnal obliterative shading.



FIG. 91. Mbega Monkey—a 'ruptively' and 'secantly' colored forest mammal. His light brush and long side-fringe carry outward into his surroundings his sky-vista-like patch of light, which 'cuts his form to pieces.'
Photographed from nature by C. G. Schillings. (Cf. Figs. 88-89.)





SUNRISE OR SUNSET.

By Abbott H. Thayer.

Presenting the very colors of the Spoonbills.

[See Plates IX and X.]

ROSEATE SPOONBILLS.

In morning or evening sunlight.

By Abbott H. Thayer.

[See Plates IX and X.]

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CHAPTER XXII

MAMMALS, CONCLUDED, ETC. PATTERNS OF MAMMALS THAT LACK DIURNAL OBLITERATIVE SHADING. SKY-MATCHING PATTERNS OF MAMMALS, AND A COMPARISON BETWEEN THEM AND THOSE OF BIRDS. FIXED 'DAZZLING' MARKS, AND OTHER SPECIAL PHASES OF PATTERN-USE

IN strange contrast to the many beasts whose strongly, moderately, or faintly patterned ground-matching costumes are based on full and perfect oblitative shading, are the few whose bold, clear patterns seem to defy that foremost oblitative law.* Such are the skunks (*Mephitis*, *Conepatus*, and *Spilogale*) in America, the African Zoril or Cape Polecat (*Zorilla striata*), the Madagascan *Galidictis striata* and *G. vittata*, and that queer, badger-like stinker of the Javan mountains, the Teledu (*Mydaus meliceps*). These, and many other small or medium-sized carnivorous mammals, are boldly pied with white and black—or dusky brown—and their white is all on the back and sides, while their under parts are uniformly dark.† We have here, as far as these patterns go, a complete inversion of the regular oblitative coloration. A true analysis of this case, which looks at first so mystifying, shows it to be in truth merely one more phase and token of the infallibly close correlation between animals' costumes and their environment and habits. Two diametrically different uses of *white* are equally consistent factors of animals' oblitative coloration. *White on the underside*, the usual culmination of the almost universal oblitative counter shading, serves as a neutralizer of shadow, an adjuster and maintainer of the even balance between light and dark; *white on the upper side*, as worn in various forms and proportions by a good many animals, serves to imitate, to picture, the shining sky from which the underside is shaded. On the one hand, it is an all-important *ingredient in an*

* See footnote, p. 123.

† The "white" of these animals is in reality pale yellow, brown, or gray.—A. H. T.

obliterative compounding; on the other it is used, at its face value, for direct 'background' picturing. Skunks, teledus, and the rest, long believed by naturalists to be colored for warning conspicuousness (proclaimant of their foul defensive equipment), have, in fact, the universal obliterative coloration. *Seen from above on open ground*, as men commonly see them, they are sometimes very showy beasts, with their big, skylit patches of yellowish white, and their darkly shadowed undersides. But how different is the view their terrestrial victims get of them! To these little animals—insects and small vertebrates of many kinds—they commonly loom up against the sky, towering high and huge as an elephant would above a skunk. Their big, bold patches of white and black are then about as potently obliterative as a beast's pattern can ever be—as is proved by our photographs (Figs. 95–97). According to the angle at which they are seen, their lustrous white * either nearly or exactly matches the brightness of the sky, while their dark patches are left to look like bushes, boulders, or more distant trees standing up above the horizon. All this is attested beyond question by our photographs, as the reader will agree. And he must consider that these pictures were taken in full daylight—a far severer test of such an effect than the dim light of night. For at night, sky and sky-pictures being correspondingly and greatly dimmed, the casual discrepancies of shade between them are reduced to almost nothing. The whole illusion, of course, is better in a dim light, since it depends wholly on bold, simple counterfeiting of background 'values' or shades. Skunks, and most or all of the other mammals that are colored like them, are grubbing terrestrial hunters, and *nocturnal*, and hence are served by their boldly pied white and black patterns in the manner shown by our pictures, but on the whole even more potently, by virtue of the dimness of the light in which they commonly hunt. The white stripe on the Common Skunk's forehead and snout—a marking shared by several other grubbing ground-beasts, and among them some with light colored bellies, e. g., the badgers (*Meles* and *Taxidea*)—plays an im-

* The actually *pale yellow* hairs are so lustrous as to look brighter, in such views, than lusterless pure white could.



FIG. 55. (Common Skunk as he appears to mice, grasshoppers, and other small ground-animals—his dark passing for distant trees, or bushes, his white for sky.)
Photograph, outdoors, from a stuffed skunk-skin. (Slightly rounded.)



FIG. 97. Mouse's or 'Cricket's' view of the Common Skunk, as in FIG. 55, etc.
Photographed outdoors from a stuffed skin.



FIG. 96. Side-view of Common Skunk, his white indistinguishable against the sky. [cf. FIG. 95, etc.]
Photograph, outdoors—stuffed skunk-skin.



FIG. 98. Common Skunk, as in FIG. 97, but with sky 'back-ground' cut off by dark, making his white conspicuous.
Photographed outdoors from a stuffed skin.

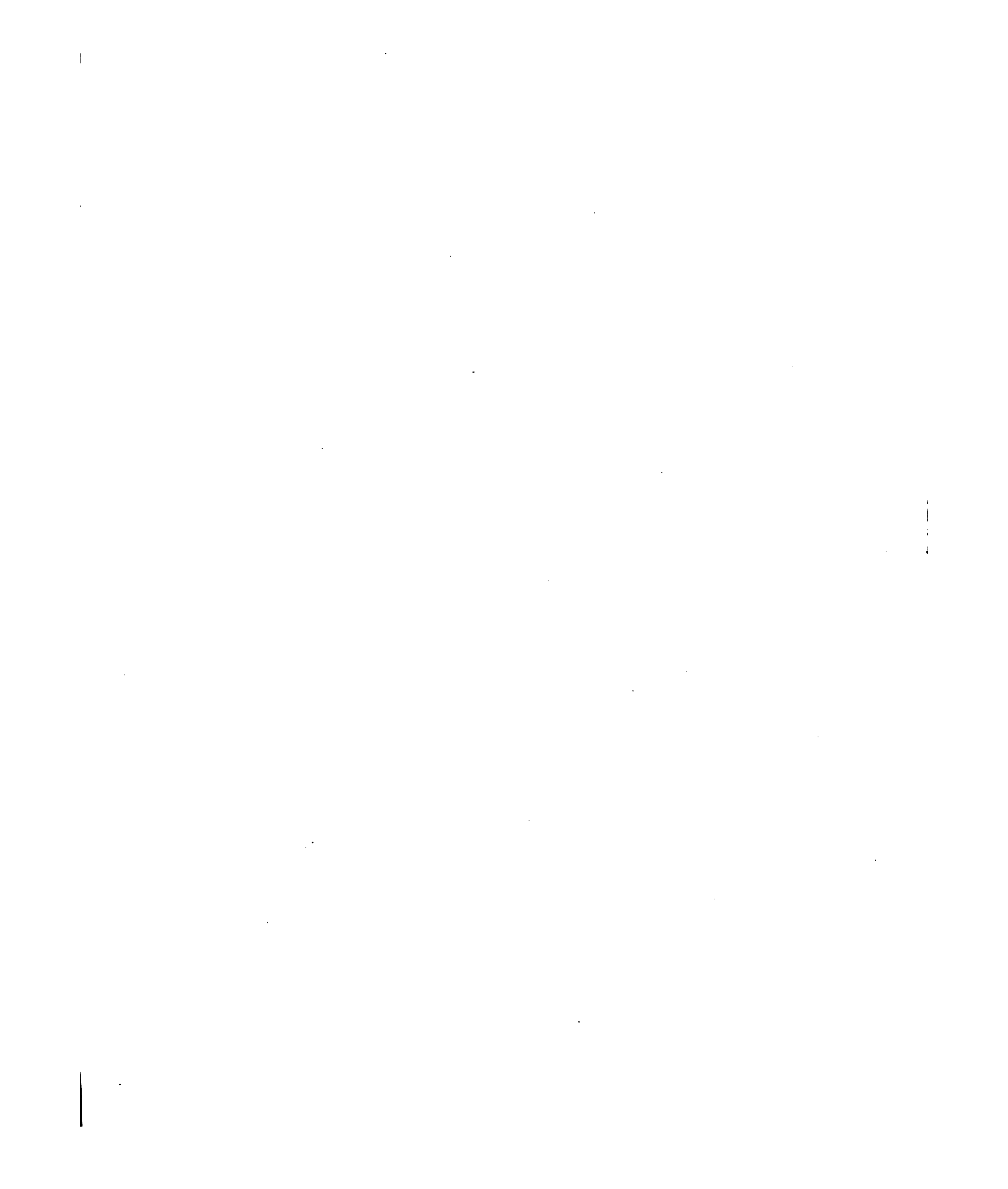




FIG. 99. Conepatl or Prairie Skunk, seen from his prey's point of view. [Cf. Fig. 95.]
Stuffed skin, outdoors, photograph.



FIG. 100. Conepatl or Prairie Skunk, as in Fig. 99, but with sky background cut off. [Cf. Fig. 98.]
Stuffed skin, outdoors, photograph.

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portant part in his disguise. As he shambles over a field, with his seeking snout held close to the ground, this white stripe, in the view of the little ground beasts he approaches, 'lets down the sky' through his black head and fore-shortened bulky body, splitting the apparition into narrow, un-beast-like halves, which look like sticks or weeds or more distant bushes or boulders showing above the horizon. The several variations in the form and proportions of the sky-picturing white top-patterns of skunks and skunk-like beasts are all in more or less obvious conformity with differences in their wearers' ways and places of life. Thus the Common Skunk's main white pattern has a somewhat irregular, a waved and insected, lower outline; while that of the Conepatl or Prairie Skunk (*Conepatus mapurito*, etc.) is square-cut and straight; and these differences are doubtless, nay, obviously, matched by differences in the beasts' average backgrounds. For the eastern skunk is more often seen against a sky-line broken by trees, stones, and bushes, than is his desert-haunting relative. (Compare Figs. 99 and 100 with Figs. 95 and 98.) Although these photographs are from shapeless stuffed skins, they can be trusted in the matter of the main effects of the beasts' patterns, and even the main pattern-differences between the two species. Evidently, the Conepatl has just so much of his back sharply and levelly cut off by white, as, in the average view of the little ground beasts he hunts, at the moments when it most profits him to be concealed from them, would show above the (unbroken) horizon. The pattern of the common eastern skunk renders the same service, but with the difference that it represents a sky-line notched by trees, etc., as we have seen. The Teledu of Java is marked much like the Conepatl, though its white 'blanket' is narrower. Other beasts with more or less nearly the same habits, and the same general system of sky-picturing, are the Ratels (*Mellivora capensis* and *M. indica*), the Wolverine or Glutton (*Gulo luscus*) in some pelages, the Great Ant-eater (*Myrmecophaga jubata*), the Tamandua Ant-eater (*Tamandua tetradactyla*), and, to some extent, the Tasmanian Devil (*Sarcophilus ursinus*). But most of these beasts have even browner (or grayer) 'white' patterns. Many of them, on the other

hand, like several of those previously mentioned (skunks and badgers), have head- and face-masking as well as body-masking sky-picture patterns. Such markings, indeed, are very common among grubbing carnivorous and insectivorous mammals. Anyone who will seek through a big museum collection of mammals will be able to add many cases of both sorts to the above casual and fragmentary list. The profusely striped top-pattern of the *Spilogale* and the *Zoril*, etc., is merely another form of the same costume, and performs nearly the same service. It pictures sky seen through obstructing twigs or narrow leaves, and is, with little doubt, significant of more sylvan or bush-land-haunting habits on the part of its wearers. It looks somewhat, also, like the converse of such a sky-scene—sharply contrasting linear lights and shadows on the ground, in moonshine. But the light markings, being almost white, are over-bright for this ground-picturing service, whereas they exactly fit the other. True, the effect of such brilliant, sky-lit stripes, contrasted with the shadowed black of the under parts, is powerfully ‘ruptive’ in all views, even against the ground, ‘breaking the beast up’ into un-beast-like stripes and patches. Indeed, against the most brightly moonlit and most sharply shadow-brindled ground, such a beast must be pretty well obliterated, and even his motion may be masked,—by the motion of the ground-shadows, cast by wind-swayed vegetation. But such conditions are highly occasional, and against open ground the *spilogale*’s mantle of white stripes must often reveal him, especially when he moves about. It would seem that he might be much better equipped for concealment in almost all such views if he were counter shaded and more softly striped—or mottled, or even wholly unmarked. Think how ghostly-illusivous against moonlit ground are the obliteratedly shaded and faintly patterned hares, and kindred beasts! Apparently, the dominant use of the *spilogale*’s pattern is not ground-picturing, but the matching of sky glimpsed through dusky obstructions—a purpose which the obliteratedly shaded, dimly patterned animal’s costume could by no means serve. (See Fig. 103.) The *spilogale* probably has few large enemies to fear, and—just as with skunks, *teledus*, etc.—it is evidently of most

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FIG. 101. Spilogale, or Little Striped Skunk, seen from mouse's and cricket's position—his dark stripes passing for vegetation, and his white stripes for the sky. [Cf. Figs. 95-99.]
Stuffed skin, outdoors, photograph.

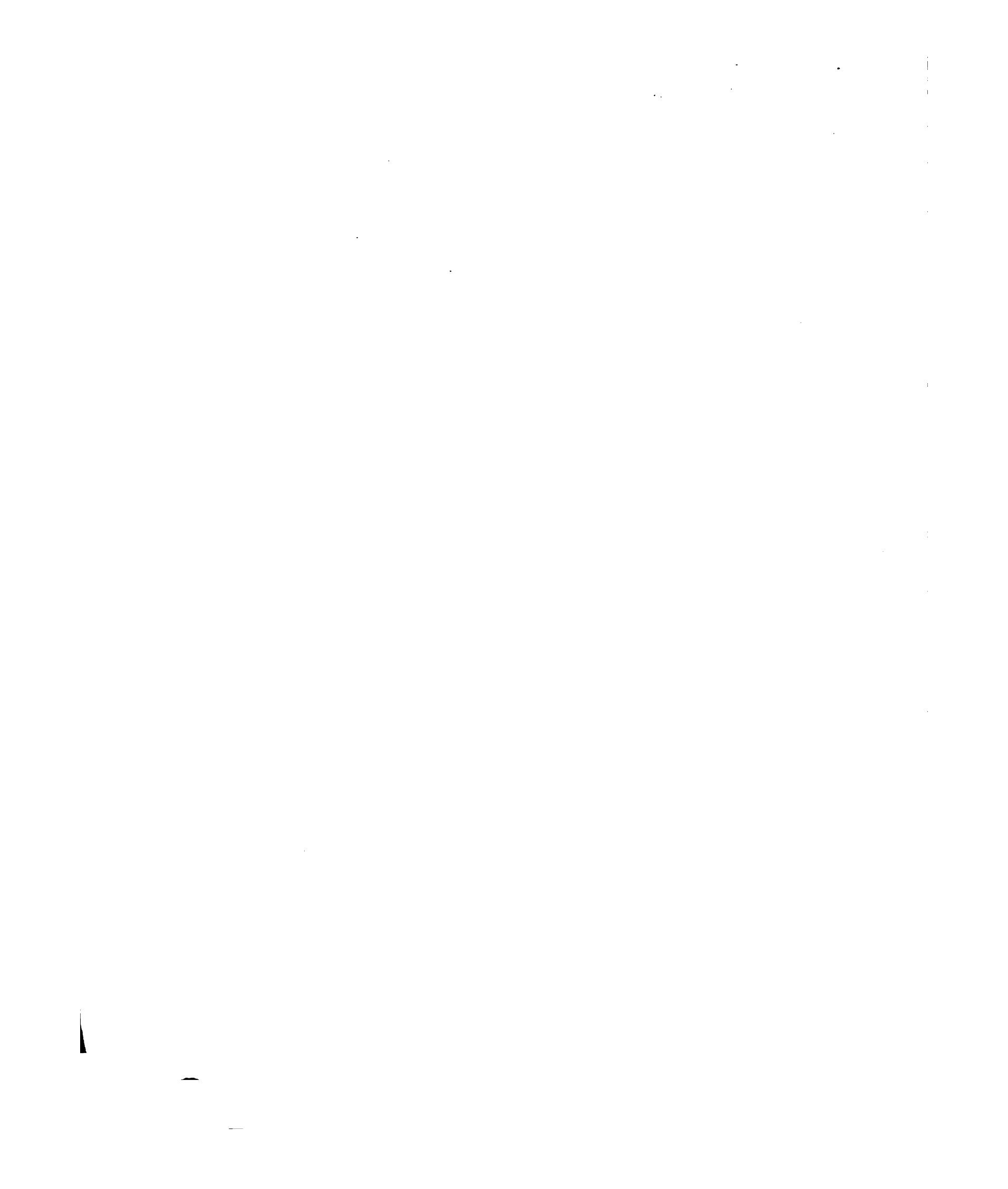


FIG. 102. Spilogale, or Little Striped Skunk, seen from men's and hawks' point of view. [Cf. Fig. 101.]
Stuffed skin, outdoors, photograph.



FIG. 103. A Compound Picture. (Photographic, except for the upper rear-view of the Hare. The crouching Hare was photographed from life; the Skunk from a stuffed skin.) This picture, by showing the old familiar type of obliterative coloration alongside of the obliterative effect of white discoloration, so long supposed to make their wearer conspicuous, prepares the reader to discover that all patterns and colors whatsoever, of all animals that ever prey, or are preyed on, are, under certain normal circumstances, obliterative. Animals which need to escape notice when looked at from above, match the sky, or whatever combination of sky, vegetation, etc., commonly forms their background from this view-point. Between these two extremes—if we count sky and sky-reflected-in-water as well as ground and water—there are ranged the color-schemes of most of the animal kingdom.

In this illustration the Skunk against the sky loses the white parts of his silhouette, and his dark parts, and his white, though often, as here, conspicuous in itself, has a largely inorganic and deceptive contour, and left to look like bushes, etc., in the background (A). On the other hand, the Skunk against the ground, when seen from the position of a mouse or cricket, as in (F), and in the detached figure of a Tame Hare, (G). If a mouse could see him, he would know the skunk to be obliteratively colored, but would consider the hare, except when it was running away from him, as a conspicuous animal, thus reversing men's notions. In this illustration, the hare in profile against the sky would be still more conspicuous were his members extended for action, showing a more revealing outline. [Cf. the Domestic Hare (G).]



importance to him to be masked for the eyes of the little ground beasts on whom he feeds. (See Figs. 101-102.)

Seen against snowy ground, which is common enough through a large part of the eastern skunk's range, a boldly pied pattern of white and black, such as he wears, is of course most potently 'ruptive.' But it does not truly *obliterate*, because all the *black* part of the beast is left rankly conspicuous, and has too peculiar a form, in such a view, to be easily ignored, or mistaken for a landscape-detail. Northern skunks, however, vary a good deal in pattern, and the very *whitest* of them are doubtless well disguised, in certain views, against snowy ground, particularly amid trees and sticks and stones and bushes and other inanimate dusky details. In this case, as throughout the whole great field of phenomena we are studying, it stands to reason that a special development of costume must serve minor as well as major ends.* But however potently 'ruptive' (and therefore essentially *obliterative*) in their effect when seen against the ground the whitish patterns of skunks and skunk-like beasts may sometimes be, the paramount function of these patterns is certainly the picturing of sky, as our figures show (Figs. 95-103). Both uses are served, perhaps almost in equal measure, but with the balance of importance probably tipped somewhat toward the *ground-matching* function, by the wholly or almost wholly white costumes of several snow-land animals. Such—to begin with those least remote from the skunks—is the rare, bear-like *Ailuropus melanoleucus*, of Thibet; such are the Arctic hares and foxes, the boreal weasels and some of the boreal hares, and the Polar Bear. Almost all of these, and their counterparts among boreal and Arctic birds—the ptarmigans, the snow buntings, the Snowy Owl, and the White Gerfalcon—almost all of them, mammals and birds alike, have a few sharp black markings in their mainly immaculate white costumes. These evidently serve as what may be called 'distractive' or 'fixed dazzling' marks. They are, in most cases, too small to show except in a very near view—when, by their sharp but isolated

* Or, in terms of the Natural Selection theory, that each development is the product of the sum of all its uses, big and small.

they tend to draw and hold the eye's attention that it less readily discerns the faintly visible details. The working of this principle is illustrated by ptarmigans have black tails, which, folded together when the bird is skulking, show as narrow vertical lines to a point away from the bird's head, thus presenting it with a view of what might be called landscape-detail. Some ptarmigans have a black face-mark, which serves to emphasize the bird's head and lustrous eye, in the case of the Snow Owl and the White Gull. Many birds have black marks. Notwithstanding the presence of such markings, they all tend to be overlooked. For if they did not *also* have the ability to run and fly they tend to reveal themselves in their white winter plumage. Thus Bears and Arctic Foxes have black snouts and dark eyes, and they habitually close their eyes, thus making themselves less conspicuous. The little Tibetan Fox has a black eye and a narrow black line around its eyes. The little Tibetan Fox is conspicuous against a background of dark firs, heathers or bushes, and presumably for life amidst background of snow. The Kamchatkan white-shouldered Sea Eagle has the dark preponderates over the white. The function and function of mammalian sky-matching is to 'obliterate' fleeing deer. That is the 'obliteration' of fleeing deer. The black bears belong in this same class of obliterative patterns.



FIG. 104.

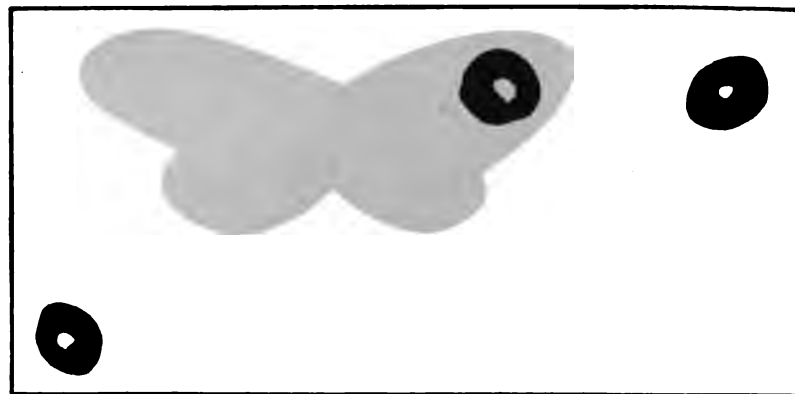


FIG. 105.

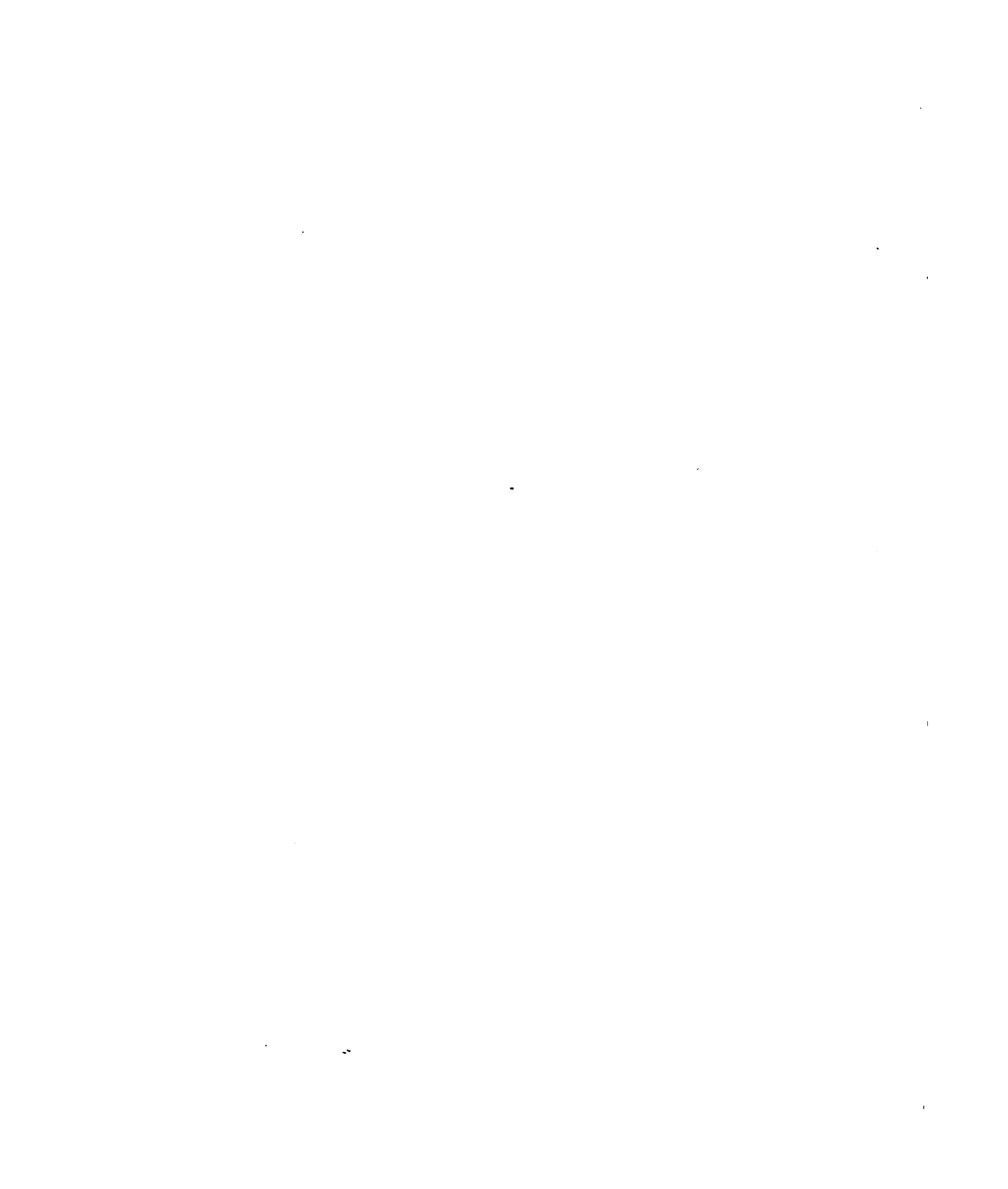
FIGS. 104-105. These diagrams illustrate the obliterative effect on faintly-showing contours of sharp and strong internal marks. The reader will see, if he *recedes* from the picture, that the Butterflies' or Letters' contours near the bold marks *vanish*, while those apart from markings remain perfectly distinct. The markings, at the same time, ally themselves to kindred details in the background.





FIG. 106.

FIG. 106. Here the spectator will discover, if he recedes far enough, (seven or eight yards in a bright light) that all three of the monochrome butterflies, even the dimmest, can be seen further, or in a less illumination, than the normally and brightly patterned one. This latter *fades first*. This shows how contrasted juxtaposed color-notes efface each other, so that contrary to the old theories they are not so good as monochrome for revealing the wearer, even in the open, while, seen through the average tracery of out door vegetation, they almost *guarantee* disguise and concealment. See Plate V.



antelopes, hares, etc., by white tails and rumps. More characteristic even than the grubbing carnivores' sky-matching *head*-patterns are these more or less 'eclipsable' rear-end flight-masks of timid, fleet ruminants and larger rodents. When these beasts flee at night before terrestrial enemies—which are nearly always of lower stature than their quarries, and in most cases additionally fated to look *upward* at them by the fact of the quarry's high-jumping gait, and their own crouching and slinking—when these hunted beasts flee thus, their *brightly displayed sky-lit white sterns blot out their foreshortened bodies against the sky*. In the night, the illusion must often be complete, and most beneficent to the hunted beast, who by its aid may often just avoid the lion's or the tiger's or the cougar's or the cheetah's killing second spring;—vanishing into air, as it were, before the predator can get his aim for the leap, or before he can perceive the direction of his quarry's flight. For photographic illustrations of this marking's obliterative effect, see Figs. 107-115. Such rear-end sky-pictures are worn by most fleet ruminants of the open land, and by many rodents with more or less nearly corresponding habits—notably the hares, and several smaller running or leaping rodents whose terrestrial enemies are many of them beasts of low stature—like weasels, minks, snakes, etc., and foxes, that slink and crouch. The ruminants that lack such markings are most of them either extremely big and powerful—like some of the huge African antelopes, and almost all the *bovine* beasts—or else they live in dense tropical forests, where at night there is very little 'overhead' light for them to relieve against. Some of the little South American jungle deer are good examples of this forest-haunting class.

All these various sorts of wonderfully effective sky-picture patterns are worn by animals that are habitually or most commonly *looked up at*, either by their enemies or by their quarries. Indeed, the presence or absence, the high or scanty development, of such markings in an animal's pattern, seems to be a direct and accurate indication of whether, in the average view of the creatures from whom it most profits the animal to be concealed, it comes above or below the horizon line—and of the largeness of the preponderance in either





FIG. 111. The common aspect of animals showing against night sky, if they have *no white top-patterns*.



FIG. 112. (Dead) Northern Hares seen from the level of a creeping fox.
These photographs show that from this viewpoint the so-called banner-mark, the *white*, is precisely what does *not* show.



FIG. 113. Dead Northern Hare, seen from men's level.
Hares in danger from over-head foes, e. g., *birds of prey*, doubtless resort to crouching 'invisible' rather than to running, while, on the other hand, enemies which *trail* them force them to leap away.

Photographed, out-doors.





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Photographed, out-doors.

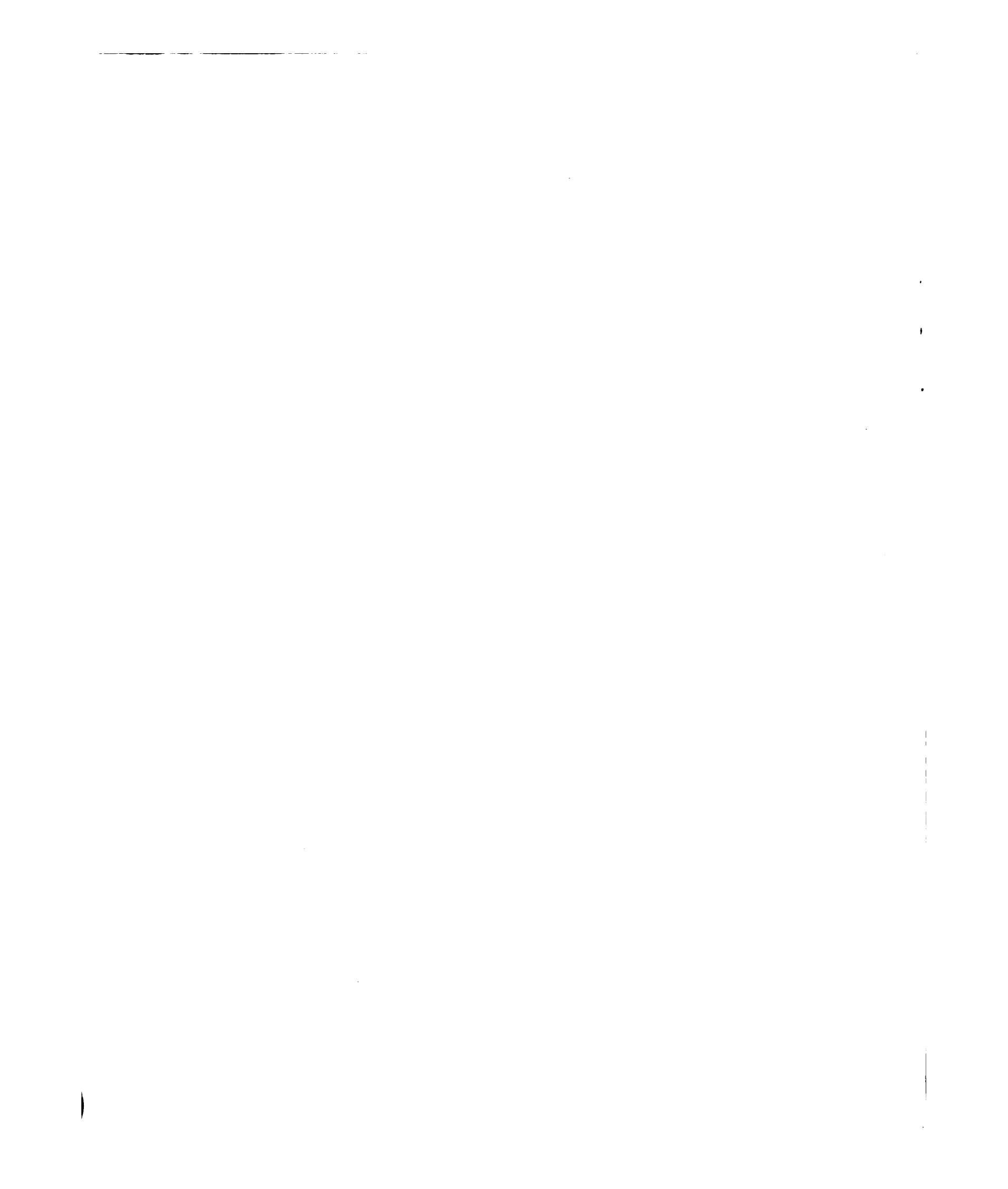




FIG. 114. White card, as in Fig. 115, but invisible against the sky, because the camera was lower than the card, just as a panther or fawn would be lower than the deer's buttocks.
Photograph.



FIG. 115. A white card—as it were a detached rump-mask against the 'ground.'
Photograph.

look like a real sunset or dawn, repeated, on the opposite side of the heavens,—either east or west as the case may be.

All these white and pink (or red) fishing-birds and vegetable-eaters have the habit of staying more or less quiet, for longer or shorter periods, in the near vicinity of their aquatic prey and enemies. Egrets and white herons stand hour-long motionless or wade cautiously about in shallow ponds, rivers, lagoons and estuaries,—ready with poised head and lancelike bill to stab the first fish or frog that comes within their reach. (See Figs. 116-118.) White pelicans fish while swimming; but the brown pelicans plunge headlong from on wing into the water, catching their prey by violent abrupt assault, like the gannets, the terns, the kingfishers, and the Osprey; and all these *plunging* fishers have characteristics of coloration in common, which are not typical of the *stealthy* fishers. These consist in brilliant ruptive patterns, chiefly on the head, but sometimes also on the wings and body—patterns which doubtless have the effect of confusing the suddenly assaulted quarry as to the exact position and the true form of its attacker. Such are the tern's black head-caps, the black or dark marks about the base of the Common Gannet's pale sea-green bill, the clearly-contrasted brown and white stripes and patches of the brown pelicans' heads, the motley costumes of kingfishers, etc. At the instant of attack, such markings 'break up' and confuse the apparition of the attacker, doubtless often to the bane of the attacked, whose life or death must often depend on the turn of a hair toward quicker or slower, surer or less sure darting off. *Stealthy* fishers, on the other hand, would in many cases be misfavored by such 'ruptive' markings, which during their quiet stalking and watching would increase their conspicuousness against the sky. On the other hand, even the black wing-tips and like markings of gannets and other *plunging* fishers, serve as 'dazzling' and 'distractive' marks,—like those of the tails of winter ptarmigans and weasels—at the moment of the bird's arrowy arrival with part-folded wings (and tail) among his finny prey.

Then there are two or more classes of animals merely *patched* with sky-pictures. Such are the more or less largely white-backed skunks, and kin-

dred mammals, and the many arboreal birds and several arboreal mammals which have biggish white spots or patches on their backs and sides. The ground beasts of this group are, as has been explained, specially equipped for concealment against the horizon-bordering sky; while the tree birds' and tree beasts' more or less ample, irregular patches of sky-picturing white are in evidently just proportion to the greater or less amplitude and frequency, in their average backgrounds, of sky vistas, and light foliage vistas amidst dark leaves and twigs and tree trunks.

Next and last in order come the terrestrial and semi-terrestrial birds and other animals which are equipped for concealment against the *landscape below the horizon*, and have little or no hint of sky-picturing in their costumes. Such are many woodland ground birds, notably the brown tropical ones described in Chapter XIX. Such also are most of the terrestrial woodland mammals; such, again, are snipe, goatsuckers, and many of the small, close-lying *Galinae* (most arboreal species have fragmentary sky-pictures—see the Cock Ruffed Grouse in Plate II); such are most frogs and toads and many ground lizards; such are sand crabs; and such, in the most marked degree, are many terrestrial snakes—for instance the Copperhead, shown in Plate XI (Chapter XXIII). Most of these creatures are patterned with elaborate ground-pictures, and on some species, like the Copperhead snake, these have reached a very high degree of specialization. Because of their low stature and their ground-haunting, close-lying habits, such animals as these scarcely ever, in the view of predators or quarries, stick up above the horizon line. They are colored, with exquisite efficiency, for obliteration or extreme inconspicuousness when looked *down at*, against a background of mother earth and her lowly vegetable mantle. If men were Lilliputians, and looked *up* at the flanks and back of the Copperhead snake, as in reality they look *down* at the sky-picturing back-pattern of the piebald skunk, the snake's coloration would seem to them just as "conspicuous" and inappropriate for disguise as the skunk's has always seemed. "It's all in the point of view;"—and if we would learn the true, the compellingly apparent significance of animals' costumes, we must

ROSEATE SPOONBILL.

Before sunrise or after sunset; matching the sky behind it,
(i. e., the western sky at dawn, or the eastern sky at sunset).

SUNRISE OR SUNSET.

A typical sky, much like the aspect of the Flamingoes.

RED FLAMINGOES.

Before sunrise or after sunset, matching the sky
behind them, as in the Spoonbill picture.

By Abbott H. Thayer

These various sketches of Flamingoes and Spoonbills show how wonderfully such birds match or reproduce the colors of morning or evening skies to the eyes of the inhabitants of the water in which they wade—both their enemies, such as anacondas, alligators, sharks, etc., and such of their prey as can see them.

Commonly, the bird's upper outline 'melts' into the sky, leaving the rest of his contour, seen through the water, agitated and muddied by his feet, to be lost in the indeterminate color-mass of the flock. Shaken and jumbled by the continual agitations of the water, the image of the flock retains, for eyes beneath the surface, only its color and its position, both of which coincide with those of the dawn or sunset, (though on the other side of the heavens) or the flushed sky opposite.

Through all stages of twilight this living mass, seen against the less lighted parts of the sky, blends into it, undergoing kindred changes of illumination, and when full sunlight bathes it, its lighted side blazes out into a perfect representation of the dawn or sunset itself, though in the opposite quarter. In the case of the Red Flamingo the bird's legs, including its feathered thighs, are purplish instead of orange-red, in keeping with the color-gradation of the sky, which is, at these hours, commonly purplest at the lowest point, having its purest reds and oranges a little higher up. Thus, each part of the bird has every possible opportunity of matching its background.—A. H. T.

ROSEATE SPOONBILL.

(i) at the western sky at dawn, or the eastern sky at sunset; (ii) before sunrise or after sunset; matching the sky behind it.

SUNNIE OR SUNSET.

A typical sky, much like the aspect of the Flamingoes.

RED FLAMINGOES.

Before sunrise or after sunset, matching the sky behind them, as in the Spoonbill picture.

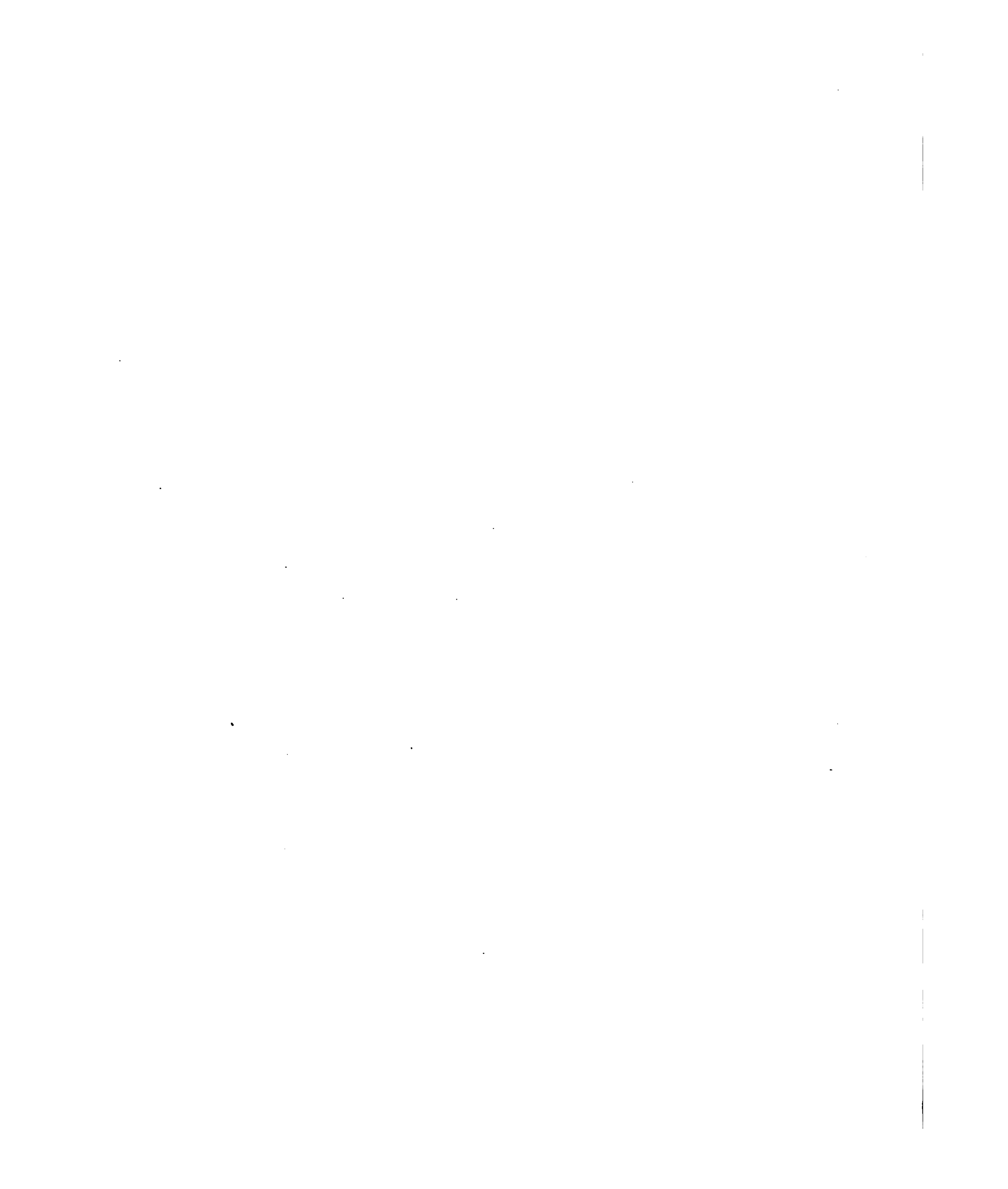
By Albert H. Tennyson

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Commonly, the bird's upper outline, "into the sky," leaving the rest of his contour, seen through the water, agitated and undulated by his feet, to be lost in the indeterminate color-mass of the hook. Shaken and jumbled by the continual excitations of the water, the image of the hook retains, for eyes beneath the surface, only its color and its position, both of which coincide with those of the dawn or sunset, (though on the other side of the horizon) or the hued sky opposite.

Through all stages of twilight this living mass, seen against the less lighted parts of the sky, blends into it, undergoing kindred changes of illumination, and when full sunlight bathes it, its lighted side passes out into a perfect representation of the dawn or sunset itself, though in the opposite quarter. In the case of the Red Flamingo the bird's legs, including its feathered thighs, are purplish instead of orange-red, in keeping with the color-gradation of the sky, which at these hours, commonly purplest at the lowest point, having its purest reds and oranges a little higher up. Thus, each part of the bird has every possible opportunity of matching its background.—A. H. T.





WHITE FLAMINGOES

In morning or evening sunlight.

RED FLAMINGOES

In morning or evening sunlight.

THE SKIES THEY SIMULATE.

The bright parts consisting of the very same color-notes as those in the sketch of the birds themselves.

By Abbott H. Thayer

These sketches are placed in conjunction only to show how absolutely similar their colors are. Of course a Flamingo seen *against* dawn or evening sky would look dark, like the palm in the lower left-hand figure, *no matter what his colors were*. The two right-hand figures, then, represent the *lighted sides* of Flamingoes at morning or evening, and show how closely these tend to reproduce the sky of this time of day; although always, of course, *in the opposite quarter of the heavens* from the sunset or dawn itself.

—A. H. T.

ATTENTION: DIRECTOR

TO: SAC, NEW YORK
FROM: SAC, NEW YORK

RE: [REDACTED]

DATE: [REDACTED]

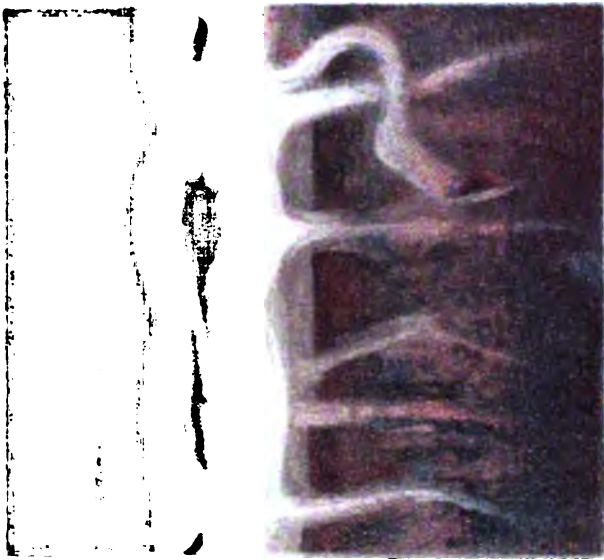
BY: [REDACTED]

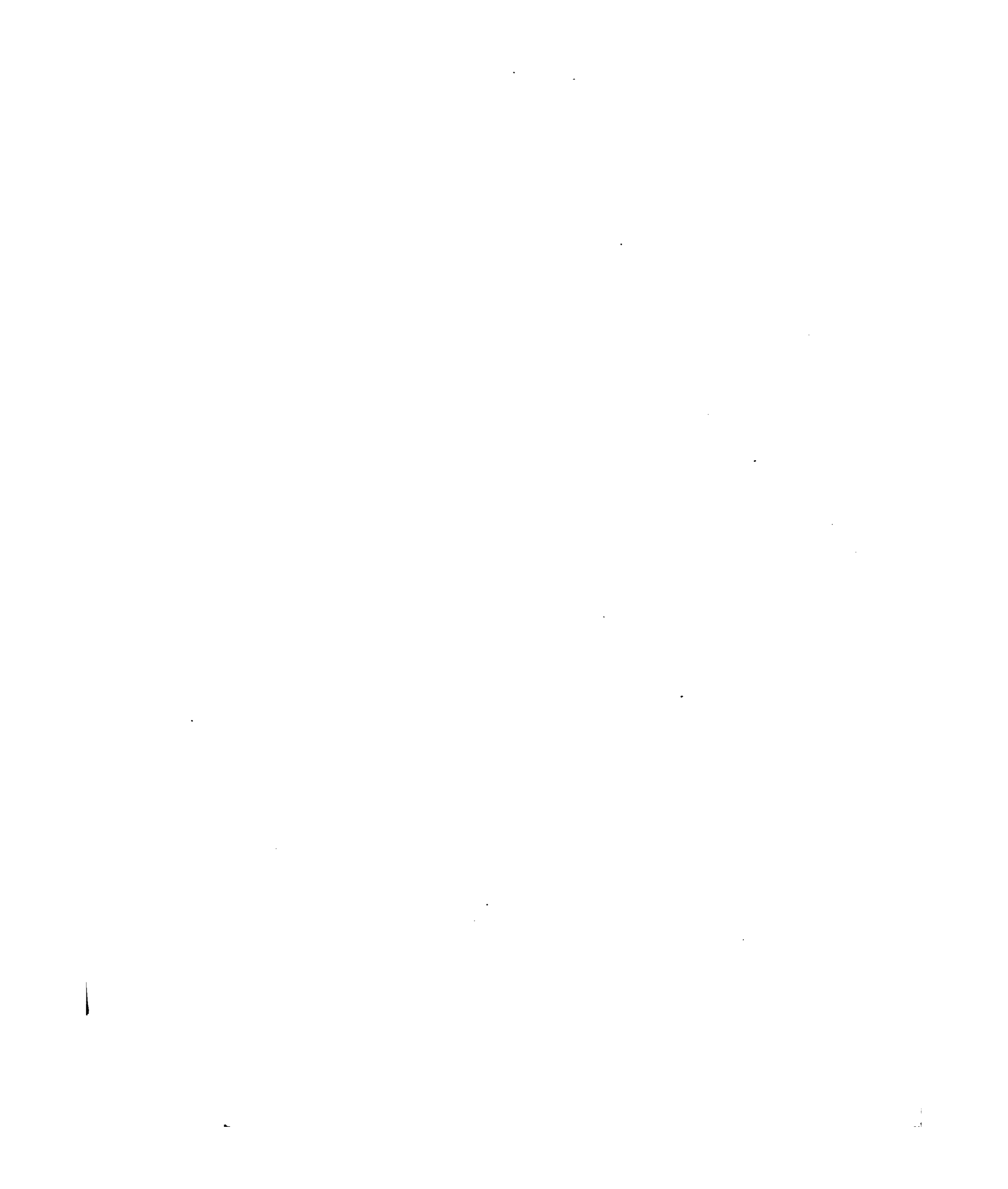
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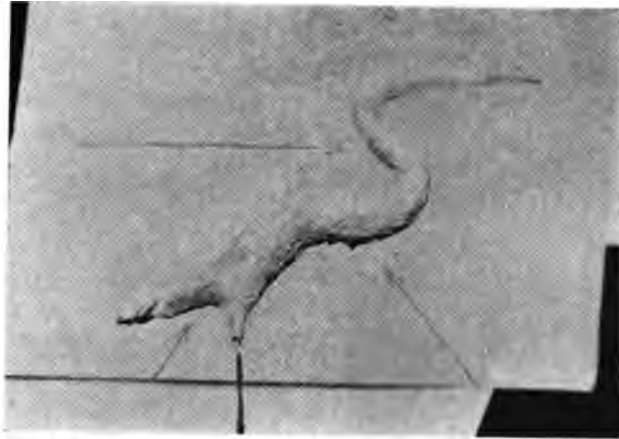


FIG. 116. Imitation Egret without plumes photographed against white (substituted for sky), to show that the shadows which reveal the form come at the *very points normally covered*, at the breeding-season, by the so-called "nuptial" plumes. These points are indicated by the arrows. The knife-like thinness of the throat, where plumes would incommode him, largely obviates the need of them at this point, by minimizing the shadow.



FIG. 117. Imitation Egret in nuptial dress, photographed against black, to show the position of the plumes.

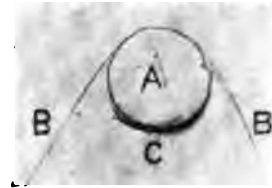


FIG. 118A. A is a section of the Egret. B the roof-like plumes. C the dark underside which they hide. The part of a heron's neck that normally bends backward as he stands has the roof's ridge-pole in front, and the eaves behind.



FIG. 118. Imitation Egret in nuptial plumage, photographed against white, showing the effect of the plumes in effacing the shadows, thus rendering the bird almost invisible when seen against the sky. This is achieved on the model, as on a real Egret, in the only conceivable way: the plumes extend downward and outward like a roof between the beholder's eye and the shadow to be covered. Because of this roof-like position, they stay illuminated throughout their whole length, and interpose their bright fringe between the beholder and the shadowed undersides of the neck and body. The fact that these fringes cross the bird's contour, and follow that of the vegetation in which he stands, greatly helps the concealment. White fluffs or fringes of this general character, screening the too deeply shadowed abdominal space, between the legs, are very common among birds and mammals.

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first learn to look at them not solely from the point of view of man, who neither flies nor climbs nor crawls, but also from that of the other animals, big and little, winged and creeping, with whom the bearer of the costume in question has in any way to deal. And by no other phenomenon of oblitative coloration is this fact so forcibly brought home to one's mind as by the perfectly consistent and unbrokenly intergraded chain of sky-picturing and ground-picturing patterns and costumes of birds and mammals.

One more notable phase of sky-picturing's occurrence on *birds* must here be cited, namely, its part in the costumes of some *ground birds* of the open land. The American Bobolink (*Dolichonyx oryzivorus*) for instance, in the summer plumage of the male, is marked and colored much like a skunk—as its colloquial name "Skunk Blackbird" attests. Roosting at night in weeds and grasses some inches above the ground—as it almost certainly does—it is disguised, for the eyes of prowling predators, almost exactly as the skunk, himself a prowling hunter, is disguised for the eyes of smaller ground animals. The Black Lark Bunting (*Calamospiza melanocorys*) of middle western North America, likewise a bird of the open ground, has a big, sky-matching white patch on its wings; and several Longspurs (*Calcarius*, etc.) and Larks (*Alaudidae*) have markings of the same nature, and kindred habits.

Sky-picturing marks are sometimes found in evident coöperation with wholly different disguising effects. Thus the common American Raccoon (*Procyon lotor*) has a rim of white or very pale brown bordering its largely dusky face; and though in many views this must serve as an oblitative sky-matching mark, like the many kindred markings of grubbing carnivorous and half-carnivorous mammals, yet it also admirably serves to make the Raccoon's whole face and head, in front view, look like the end of a hollow log or stump, with a shadowy, dark interior and light, encircling outward rim. (See Fig. 120, No. 36.) This trick of coloration, which has already been mentioned in connection with the sloths (Chapter XX), is of widespread and frequent application in the animal kingdom, as a glance at Fig. 120 will convince the reader. Here we have many kinds of 'holes' with encircling light rims or margins; some

of them real and some imitated—pictured—by the surface-patterns of animals. Some of these counterfeits are very highly developed and effective (e. g., the whip-poor-will, No. 50), while others are comparatively obscure. But even so casual a rendering of this effect as is achieved by the young owl's face (No. 1) may well benefit the animal that wears it, in the long run—since it tends to mask the creature's true structural form and look of life.

A good many mammals * have the form of 'distractive' coloration mentioned in the case of pheasants, etc. (Chapter XVII), namely, *strongly banded* tails and delicately marked (or unmarked) *obliteratively* shaded bodies. Almost all are beasts that live in holes, and dart into them in time of danger; and their banded tails undoubtedly work for their safety by diverting the pursuer's attention and attack to a point *behind* them, in the essential moment of their darting forward into their retreat. Even if they are actually seized by the tail, they may still tear free and escape—whereas a body-grip would far oftener succeed. When such beasts are quiet, their tail-bands act *obliteratively*, to the full—as we have already seen in the case of birds (Chapter XVII).

We have now examined what seem to be the main principles and many of the chief phases of disguising coloration among mammals. But, as I said before, it is likely, nay, certain, that many types of particular interest have escaped the notice of my father and me. It is true also that we should be adventuring beyond the proper scope of this book if we tried to give more than a clear *sketch*, illuminated by a few chosen representative details, of any one branch of the big and intricate general theme. Our next subjects—fishes, reptiles, and batrachians—must be considered even more briefly, owing to our very fragmentary knowledge of these animals.

* Spermophiles, lemurs, raccoons, etc., etc.





FIG. 119-(1.)



FIG. 119-(2.)



FIG. 119-(3.)



FIG. 119-(4.)

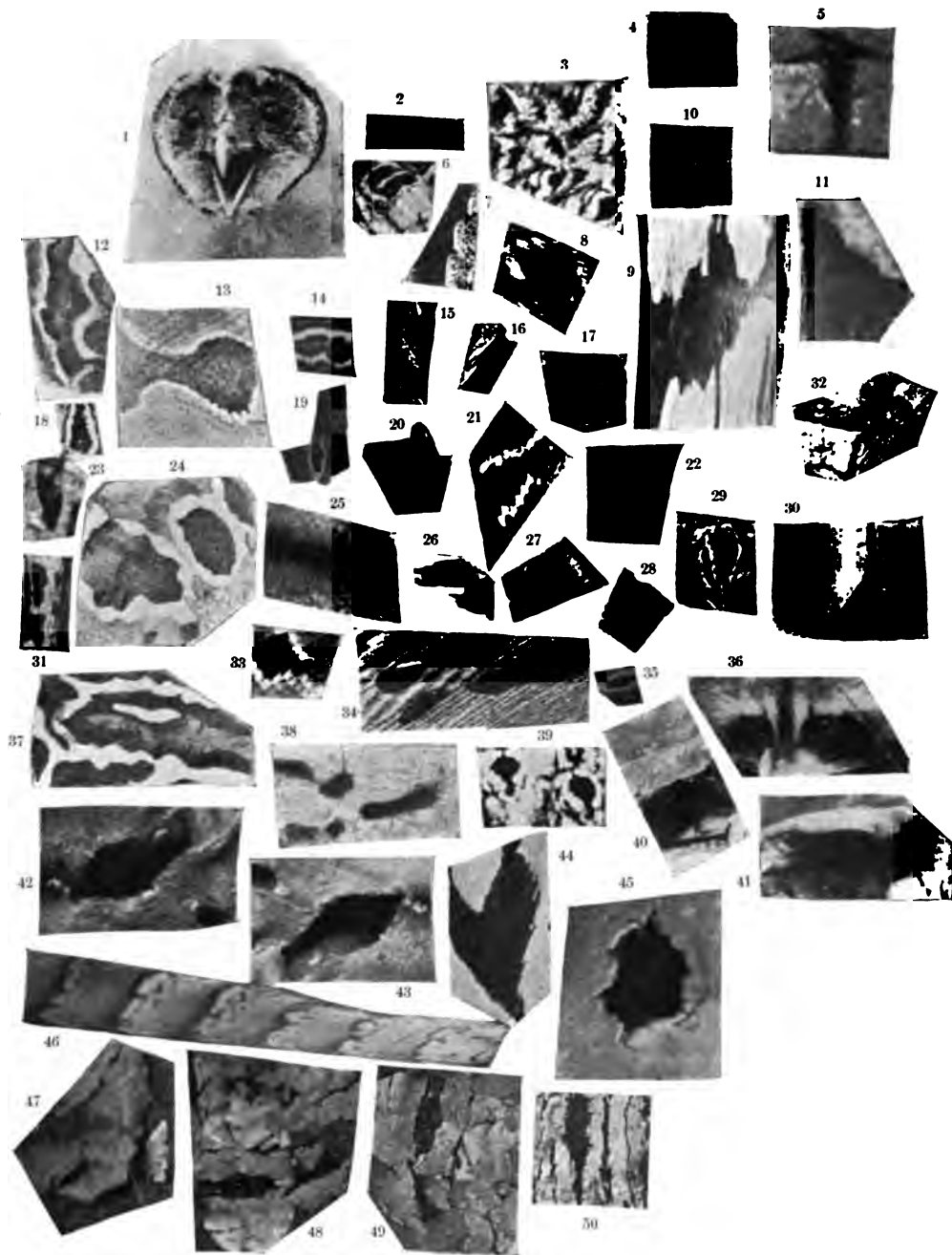


FIG. 119. Diagram to illustrate the effect of the animals' markings shown in Fig. 120. These four figures show a graduated development from No. 1, which represents nothing substantial, to No. 4, which represents an edge of substance showing against a shadowed cavity beneath. Animals' markings, almost invariably, are on the general principle of No. 4.

FIG. 120. Bits of animals' patterns, all representing holes, i. e., shadowed cavities over which sharply defined edges "relieve" (like wood, leaves, rocks, etc). Among these are mingled reproductions of actual holes to show how close is the resemblance. (See Fig. 119.)

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1. Young Barn Owl's face. Photo.
2. Bit of Boa's pattern. Photo.
3. Baby Woodcocks' (*Philohela minor*) backs and heads. Photo.
4. Hollow among stones. Photo.
5. Hollow among stones. Photo.
6. Part of adult Woodcock's head. Photo.
7. Bit of Whip-poor-will's back. Photo.
8. Bit of Rattlesnake's pattern. Photo.
9. Slivers of wood over shadow. Photo.
10. Hollow among stones. Photo.
11. Curled leaf. Photo.
12. Bit of Ocelot's pattern. Drawing from photo.
13. Bit of Python's pattern. Drawing from photo.
14. Bit of Ocelot's pattern. Photo. from half tone.
15. Split bark over hollow in a tree. Photo.
16. Bit of Whip-poor-will's back. Photo.
17. Adult Woodcock's eye. Photo.
18. Top of baby Woodcock's head. Photo.
19. Fore part of a sphinx caterpillar. Photo. from drawing.
20. Open mouths of young birds. Photo.
21. Bit of Rattlesnake's pattern. Photo.
22. Bit of Copperhead Snake's pattern. Photo.
23. Shadowed holes in a crumpled hide. Photo.
24. Markings on a kind of frog. Drawn from photo.
25. Fold in a hide. Photo.
26. Slivers of wood over shadow. Photo.
27. Bit of Woodcock's pattern. Photo.
28. Bit of Copperhead Snake's pattern. Photo.
29. Baby Woodcock's head, etc. Photo.
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49. Torn dead leaves. Photo.
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CHAPTER XXIII

FISHES. THE MOST UNIFORMLY AND NEARLY INVARIABLY COUNTER SHADED OF ANIMALS. THEIR COLORS AND PATTERNS. OTHER MARINE ANIMALS

THOUGH my father and I know next to nothing about fishes from the standpoint of systematic science, we have yet gathered, from lifelong observation of them in their element, in market stalls, in museums, and (pictured) in books, a trustworthy general estimate of the main characteristics and prevalences of their disguising coloration. As a class, they are in some respects the crowning vindication, or rather natural demonstration, of the great law of oblitative counter shading. For while in each of the classes of vertebrate land animals the exceptions to the employment of this principle are, in the aggregate, many, despite the vast preponderance of the species on which it is used, among fishes the exceptions are so extremely rare as scarcely to count at all. This is true, at least, of the fishes that live within the reach of daylight, as do almost all the kinds familiarly known to man. Cave fishes, living in absolute darkness, are blind and colorless—dull white, i. e., simple fish-flesh color, all over. *Deep-sea* fishes, though they live in perpetual night, are as a rule neither blind nor wholly without superficial color. They are sometimes whitish all over, like the cave fishes, but oftener monochrome gray or brown, without special shading, though sometimes marked with red. Thus there can be little doubt that despite the total want of daylight in the waters they inhabit, they habitually *see and are seen!* The solution of this enigma is the fact that the fishes and other deep-sea animals make and emit phosphorescent light. How generally and how largely this is accomplished we can judge only by the physical evidence furnished by the fishes' eyes and surface-colors. But it goes almost without saying that this 'home-made' (!)

light, by which the deep-sea fishes hunt and flee one another, is not such as could favor any system of oblitative shading. For it has no prevalent direction relative to the fishes, but is erratic and forever shifting, striking all their sides and planes with equal frequency. Accordingly, though colored, they are mainly monochrome, and as dark below as above. But aside from these little-known fishes that inhabit the remote abysmal depths of open ocean, and the few kinds of blind fresh-water cave fish, practically all the species known to man live in water permeated by the descending light of day. Fishes, in fact, as man knows them, are, typically, inhabitants of the bright upper and outermost border of the water, just as birds and butterflies are dwellers in the bright-colored upper and outermost fringe of the earth. These normal daylight fishes may be grouped, for our present purpose, in two main classes,* namely, the *Free-swimmers of open water*, and the *Haunters of submerged land*. This second class is again divisible into many general types, whereas the first is wonderfully homogeneous and simple. Wherever the element of *land* enters into the case, there begin the chances of almost limitless diversification in the adaptive development of the fishes' habits and coloration. But the conditions and aspects of water alone (especially beneath the surface) are, comparatively, fixed, few, and simple. Correspondingly constant and simple is the color system of the free-swimming fishes, both fresh-water and marine. Their smooth, regular forms, monotonous habits, and single method of locomotion all work in the same direction—all lend themselves fully to plain oblitative coloration, founded on pure and perfect oblitative counter shading. The gradation of shades and tints—from silvery-white bellies to dusky backs—on almost all free-swimming pelagic and fresh-water fishes, is true and delicate and exquisite beyond description. Among fishes of the same general form and habits, however distantly related, this oblitative shading varies scarcely at all from species to species. Even their color-tones differ but little. They almost all wear exquisite, soft, water-

* Corresponding to the divisions called "Pelagic" and "Shore" fishes in ichthyological classification of the fishes of salt water.

colors—green, olive, gray, pearl-blue, silvery, deep olive-brown, etc. These tints are all components in the obliterative shading and its resultant uniform, soft, water tone, and have, in general, little independent pattern-effect. The bar of silvery blue on a salmon's side, for instance, does not flash out in its full brilliance until the salmon, in executing some swift manœuvre, turns his side upward toward the daylight for an instant. At other times, in the normal position, it is merely a link in the obliterative chain of graded shades, looking almost uniform alike with the salmon's actually dusky back and his actually white-silver belly. But any 'liquid' tinges of more vivid color which these iridescent areas do superimpose on the general 'flat' and monochrome effect, in the fish's normal position, help his apparent dissolution into his watery background of slightly mutable and varied tints. They are the open-water fish's *markings*, as it were—his pictures of vague, intermingled water-tints. At and near the surface, there is more variety. Bubbles, and foam, and flickering, shadowy ripples, seen from below—as well as dimmed vistas, farther or nearer, of sky and clouds and sky-lit wave tops—all play a part in the regular backgrounds of surface-swimming fishes, and all are repeated, more or less plainly, in their fair, sheeny coloration and faint patterns. Most free-swimming, open-water fishes, indeed, spend much of their time very near the surface (many are even wont to leap, and a few to *fly*, above it—as everybody knows), and the delicate brilliance of their shimmering water- and sky-colors is in harmony with such habits. Another important function of their lustrousness is the *actual mirroring* of water—one more potent factor in their wonderfully efficient concealing-equipment. All brightly shiny fishes—mackerel, herrings, salmon, etc.—mirror their surroundings in this way. But even this beautiful principle is wholly subservient to the obliterative shading, and does not upset the essential balance of its working.

'Secant' and 'ruptive' patterns are not common among these fair-colored free-swimming fishes, but neither are they altogether lacking. The mackerel has a seamed "lateral line" which serves as a 'secant' stripe, and many wavy up-and-down stripes above it. A good many pelagic and fresh-water

fishes have one or more such markings, either longitudinal or vertical. But patterns of this sort seem less appropriate to an environment of water alone—particularly away from the surface—than to one in which there is some element of 'land'; and when they occur on free-swimming fishes they may be connected with their wearers' need to haunt the bottom during the breeding season. Blotchy 'ruptive' patterns are almost wholly wanting among these fishes. They occur, however, on a few pelagic animals of gigantic size,—namely, on certain whales—and possibly on some huge pelagic fishes also, though we do not know of any that are thus marked. Many of the giants among pelagic (free-swimming) fishes, such for instance as the sharks, are colored rather dingily, lacking delicate tints and lustrousness—though almost all obliteratively shaded to the full.

We now come to the second and more composite class of daylight fishes, the *haunters of submerged land*. That is, the fishes that spend all or the greater part of their lives in close contiguity with submerged solid portions of the earth—whether rocks, sand beds, coral reefs, or muddy and pebbly lake and river bottoms. They are, so to speak, the *sparrows* and *partridges* of the water, as the free-swimmers are the *gulls* and *swallows*. More than this, the submerged-land-haunters are also the parrots, toucans, and paradise birds of the water. Man's knowledge of subaquatic life and scenery is at the best pitifully inadequate, but he is able to piece out his few, fragmentary, and imperfect observations* of wild fishes in their element by an acquaintance with some indubitable general principles of their coloration and illumination, and by a comparison of fishes removed from the water, and in aquarium tanks, with terrestrial and aerial vertebrates. The conclusions reached by such means must necessarily be defective—very far from completely rounded—but they will yet be approximately correct as far as they go. To the student of oblitative coloration, who has learned to perceive the exquisite correlations between animal and environment which prevail among the creatures of earth and air, the examination of such ground-haunt-

* Subaquatic photography is destined to be of great service in this direction.

ing fishes as may come into his hands is the key to a new and strangely beautiful realm of natural scenery, which must otherwise have remained almost wholly unknown to him. For there can be no reason to doubt that the obliterated bodies of these fishes are covered with true pictures of their mysterious natural environment, so far withdrawn from human ken. Possibly these pictures never reach quite so fine a point of minute specialization as do the best of those worn by birds and butterflies, for water obstructs *sight* as air does not, and the eyes of subaquatic creatures are probably cruder (?) organs than those of the higher land animals. Nevertheless, it is evident that the predaceous fishes and other subaquatic animals see keenly, after a fashion, and also that this fashion is not so widely different from our own, because in all cases where we are able to compare the pattern of a highly marked subaquatic creature with that of its natural environment, we find a beautifully true and finely detailed correspondence between the two. From these accessible cases alone one might plausibly infer that all highly patterned fishes wear real background-pictures. But to a person with artistic sight (i. e., sight highly and truly and roundedly developed), and an understanding of oblitative coloration, a glance at any such fish far removed from its home will leave no doubt on that score, even though the *exact* nature of the fish's normal environment remains unknown. Perhaps the most familiar among the 'ground'-haunting fishes that are not quite inaccessible to our study in their homes are some of the flat-fishes—flounders, plaice, etc.—those queer creatures that have departed so monstrously from the main piscine type. Their wonderful protective coloration has long been a matter of common remark; but here as elsewhere the subtle basic principle has been overlooked. Flounders and their kindred, using one broad side as a back and the other as a 'bottom,' are indeed very nearly 'flat,' and their exposed upper side arches but little above the surface of the sand- or pebble-bed on which they rest. But a close examination shows that this 'back's' very slight convexity is exactly compensated by a delicate oblitative shading, accelerated to cope with the sharp rotundity of the back's *edges*, and, downward, culminating

in the uniform whiteness of the flat underside—which serves the usual function of shadow-neutralizing when the fish swims about. The upper side, as is well known, is not only exactly like the sand or pebbles in general tint, but is finely peppered with lighter and darker, grayer and browner, flecks, in exquisite imitation of the surface of the sand bed; or it is marked with variegated pebble-patterns, or with the two kinds in combination, or with seaweed colors and patterns,—as the case may be.* The sand-picturing patterns of these flat-fish are almost exactly duplicated by those of certain beach-haunting amphibious crabs. Such for instance is the exquisitely dainty and elusive little “Spirit Crab” of the American tropical and subtropical coasts. This little crab dwells in myriads on the flat sandy beaches of the West Indian Islands, etc.; but its oblitative shading, sand-color, and sand-picturing pattern are so potent that it is next to impossible to see it until it moves. Even then it is inconspicuous enough, though it runs with great speed. Aquatic crabs which haunt submerged rocks are marked much like the fishes inhabiting like situations. Those of northern seas are as a rule not gaudily colored, although often richly marbled and spotted and streaked with accurate rock-picturing patterns, founded always on full oblitative shading. Some of these rock-patterns, particularly those of *fishes*, are almost as minutely accurate as those worn by certain warm-blooded land creatures, such as the Nighthawk (Chapter V, Figs. 30–31). As the Nighthawk’s pattern contains an admixture of the picturing of lichens and other small and delicate dry-land vegetable forms, so the rock-surface patterns worn by fishes contain generalized pictures of seaweed, minute mollusca, etc.,—as it were the rock lichens of the water. But whereas in cold and temperate seas this superficial growth is comparatively scanty, often allowing the actual surface of the rock to show, in *tropical* waters it tends toward a completely masking luxuriance and ornateness. Particularly is this the case in coral regions. The fishes of tropical coral-shores and reefs are almost as famous as tropical butterflies

* The rays (*Raiida*) have much the same general system of coloration as the flat-fishes, though usually wanting the minute adaptive markings.

for gorgeous brilliancy of coloration and variety of pattern. This gaudiness of tropical fishes, so far from being, as most people have supposed, a mere lavish expenditure of ornamentation, on Nature's part, is merely one more beautiful evidence of universally perfected oblitative coloration. As the sunlit crown of the tropical forest is full of gaudy colors, so, and more so, is the sunlit upper region of tropical ocean water, about coralline and rocky shores and reefs, and white sand beds. What could be more natural and appropriate than that the fishes living in such places should have, in addition to their never-failing oblitative gradation of general shades, intensely brilliant colors, in rich and varied patterns? All the 'paradisaic' tropical fishes, which have so often been marveled at, are in fact merely covered with average-background-pictures, working for their wearers' concealment as truly as do the dull-colored and delicate patterns of the flounders and northern rock fishes and rock crabs. To be sure, the background-pictures worn by these 'submarine butterflies' are as a rule very much generalized, for there is redundant variation in their surroundings, and some of them are restless vagrants,—though seldom going far from the rocks or coral-beds. Doubtless there are many kinds that "lie close," and never wander far,—and, accordingly, are equipped with more minute and definite pictures of gay coralline and weedy backgrounds. But here our knowledge (i. e., that of the present writers) is defective. Nevertheless, the kinds and degrees of oblitative color- and pattern-adaptation among tropical fishes, even as we know them, are many and various—too many and too various to be described in detail here. A few more very general statements about them must suffice. Their colors (besides black and white, and all the mixed tints of gray and brown and olive) include the entire range of the spectrum,—red, yellow, blue and green being perhaps the commonest, among pure colors. These, of course, are the colors of coral, seaweeds, mollusks and other lowly marine animals, and of water over sand and stones,—or, in other words, colors typical of the fishes' environments in fertile tropical seas. The above-named tints, with very many more, occur on the fishes in all sorts of striped, banded, spotted

and blotched patterns, whose effect is 'secant,' 'ruptive,' or purely and delicately background-picturing, as the case may be. Iridescent or highly changeable color is not so characteristic of these gaudy ground-haunting fishes as it is of the free-swimmers that spend much time very near the surface. Indeed, their brightest colors are often almost lusterless—like those of toucans and parrots rather than those of hummingbirds and peacocks. This, also, is in evident harmony with their ways and places of life. For, down in ocean water, below all the surface-agitations, the light is constant and somewhat diffuse, and plays few tricks of any sort; hence strong 'dead' color, in fit background-patterns, is all that is required to complete the concealment of obliteratively shaded fishes when they lie motionless in that quiet realm. Some of the most elaborate and beautiful of the oblitative patterns worn by such fishes are on the fins, particularly the dorsal and the caudal. When the fins are extraordinarily long but *unmarked*, as for instance in the genus *Chætonodon*, they sometimes bear a direct mimetic resemblance to blades of seaweed. Mimetic in a similar way are also, probably, some of the tentacular excrescences of fishes—such as those of the "Angler" or "Hunting Frog" (*Lophius piscatorius*, etc.). Indeed, the whole lumpy form of this sluggardly "angler" suggests mimicry of a weed-grown rock or lump of coral, and its oblitative shading is, I believe, scanty or wanting. There *may*, indeed, be a good many cases of true mimicry among the fishes of grotesquely distorted form; but we have no definite knowledge of more than one or two. On the other hand, it seems that most of their excrescences and lengthened, 'painted' fins are, like the corresponding developments of birds, truly oblitative, and coöperant with full counter shading. The two uses however, are of course constantly interwoven. Some of the pipe-fishes, and other snake-shaped haunters of floating seaweed, probably bear a mimetic resemblance to flat weed-blades. But being themselves *cylindrical*, they cannot look *flat* without the aid of oblitative shading, which, accordingly, is here used for the attainment of a *mimetic* effect. (This is a common occurrence among lepidopterous larvæ, as we shall show in a later chapter.)

In addition to all the wonderful devices of *fixed* adaptive color and pattern worn by fishes, they have often the extraordinary gift of 'chameleonism,' i. e., quick, sometimes *instantaneous*, color-change. Indeed, some of them have this power in a higher degree than any other vertebrate animals known to man, their coloration being as it were 'alive,' and 'fluid'—darkening and brightening, and shifting its pattern, in swift, repeated mutation. Sometimes the changes are evoked only, or chiefly, by changes in the light which strikes the fish's surface. But no doubt the chief use of such changeableness of coloration, in most cases, is adaptability to various backgrounds. The fishes most subject to such 'chameleonism' are the gay-colored 'ground-haunters' of tropical seas,—the very ones that are notable for their lack of iridescence;—but trout and probably other fresh-water fishes are also somewhat 'chameleonic.' Mr. A. R. Dugmore, in his admirable and delightful book on Nature photography ("Nature and the Camera"), gives some interesting testimony on the subject. He, moreover, fully and clearly states the fact that even the gaudiest tropical fishes are colored for concealment. But, like all the rest, he ignores the great basic principle of obliterative counter shading, without whose aid the color adaptation would be of so little avail.

So far we have considered mainly the fishes of salt water. But of course the same general principles, with various small modifications, apply to fresh-water fishes—the inhabitants of lakes and brooks and rivers. Some of those I have already mentioned, such as the salmon and the herring, live in both kinds of water, making annual migrations from the one to the other and back again. These are all of the free-swimming type—with colors and markings not specialized to match any one sort of *ground*, but rather adapted for generalized *water*-picturing near the surface. This, the type of coloration of the generality of free-swimming "pelagic" fishes, is also, with modifications, that of the free-swimming fresh-water kinds—much more localized in habitat though they almost always are. Inland 'bottom-fish,' also, are much like marine ones, though with less variety of coloration. Some of them are 'mud-fishes,' and colored muddy brown or gray, with full obliterative shading,

but usually with scanty markings. Soft, dull mud, more or less barren of vegetable or stationary animal life, and free from stones and sand, is a characteristic fresh-water product. Such fish as the American Hornpout (*Amiurus catus*, etc.) haunt this simple element, and have a correspondingly plain and simple oblitative equipment. So do the fish-like young of many frogs and toads and salamanders—the “tadpoles,” in other words. But, as in almost all other cases, there are gradations from this type of coloration into others. The common American Brook Trout (*Salvelinus fontinalis*) varies much in coloration, having even, as I have already mentioned, a ‘chameleonic’ power of almost instantaneously changing—lightening or darkening—its general tint. The dullest-colored trout from a dark, muddy pond or brook is only a few grades above the hornpout or the polliwog in fairness of tint and elaborateness of pattern; while a light and bright one from a clear, shallow stream is one of the most exquisitely and ‘specially’ marked and colored of fishes. In the aspect of this fair trout’s common background there is a characteristic which we have not yet considered, and which in its full display is peculiar to shallow running water. That is, the system of moving light-and-shadow patterns on the bottom, made by sun-rays variously refracted from the agitations of the surface. Everybody is familiar with these beautiful water-patterns, that glide and flicker over the beds of brooks in sunlight. They are of many forms, as the surface-agitations are of many sorts; nevertheless one can distinguish a few predominant types among them. The simplest consists of more or less nearly parallel and widely separated undulant bright lines; the most complicated is a maze of twisting, branching, tremulous bright bands encircling darker spaces—*plaided*, sometimes, like the scales of a fish,—or like the giraffe’s pattern. These pretty effects are produced of course both by wind- and current-ripples; but it is the *current*-ripples that make the greatest variety of patterns. Notable among these variations are the whirlpool shadows. They are cleanly and perfectly circular dark spots, each surrounded by a bright rim of sunlight. In all brooks whose passage is in any way obstructed at the surface, little whirlpools are engendered here

CHAPTER XXIV

REPTILES AND AMPHIBIANS

GAUDY and motley-colored almost as the brightest birds, butterflies, and fishes, are some of the arboreal lizards and snakes of tropical forests. The lizards are wonderfully light and agile climbers, wanting only wings* to give them full command of the regions of airy outermost foliage, into which they freely penetrate; while the most truly arboreal snakes are scarcely less gifted acrobats, and spend much time in those realms of richest color. With both snakes and lizards, *green* is the commonest color; but red, yellow, orange, blue, etc., frequently occur on them, in various sharp 'secant,' 'ruptive,' or generalized background-picturing patterns, exactly corresponding to those of the birds inhabiting like regions, though differently modified to suit the lizard's and especially the snake's very different bodily forms. The prevalence of green in their costumes, also, is paralleled among birds, for, as we have seen, the 'lower tier tree-top birds' of the tropics tend to be green; and the strictly arboreal reptiles have almost the same local habitat.

Both snakes and lizards, and the bright-colored arboreal kinds as well as those of duller tint and humbler situation, are almost without exception obliteratedly shaded, to the full,† and this oblitative shading is almost wholly essential to their concealment. As a snake has the simplest bodily form of all vertebrate creatures, so is his oblitative shading, when complete, the

* A few kinds (the "dragons," *Dracho*) have even parachute wings, like the flying squirrels.

† Partial exceptions occur among the burrowing snakes and legless lizards, some of which have almost monochrome surfaces, and among sea snakes. They, however, have oblitative shading in gross, being dark above and light beneath, but with the two shades sharply contrasted instead of connected by intermediate tones. In this they resemble certain whales. Whether or not all the species of sea snake are colored thus crudely, I cannot say.

COPPERHEAD SNAKE ON DEAD LEAVES.

Painted from life by Rockwell Kent and A. H. Thayer. (Also G. H. Thayer and E. B. Thayer.)

This is a bona-fide study of a Copperhead Snake among dead leaves—its normal situation. So exact, on this snake, is the representation of leaves and the spaces between, that no exaggeration in the painting is possible.—A. H. T.

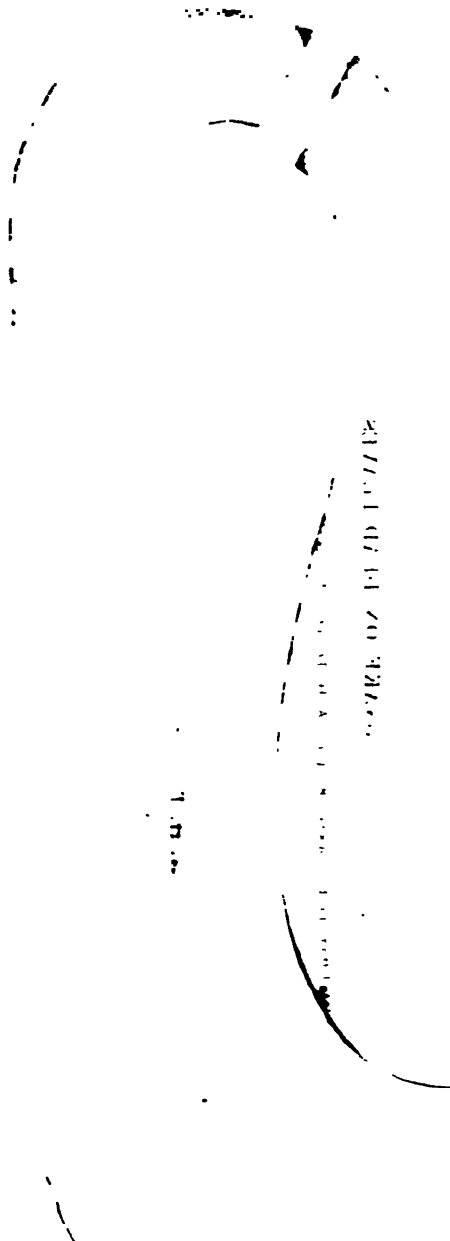
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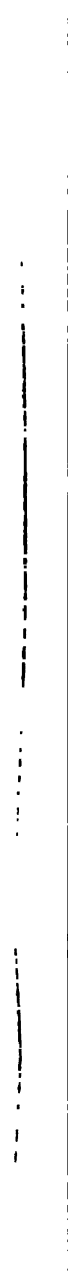




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most beautifully simple to be found among vertebrates, not excepting fishes. There can be no finer display of this great principle in full and pure application than is furnished by the common green Grass Snake (*Liopeltis vernalis*) of northeastern North America. (See Fig. 121.) Deep grass-green along the upper median line, his color shades lighter by imperceptible gradations down his sides, passing through pale straw-green along the edges of his ventral surface, and culminating in dim greenish white on the flat underside. The effect of this exquisite shade-gradation is to make the little snake appear of a uniform, intangible, grassy green, when he lies at rest or glides along, on the ground or in the bushes, in his normal position. Turn him over, so that his pale belly is uppermost, and he becomes very conspicuous—looking grossly solid (Fig. 122). He is still, on the whole, *green*, like his surroundings—but by no means ‘obliterated.’ (!) In a *normal* position, ‘flattened out’ completely by the counter shading, the snake is not only likely to look merged into his general green background of grass (or other vegetation), but, when this illusion fails, and parts of his surface definitely catch the eye, they will as a rule pass for portions of broad grass blades or flat leaf-surfaces. This is *mimicry*, after a fashion, but it is mimicry achieved only with the aid of obliterative shading—and the effect is decidedly of minor importance. Such interminglement of the two principles (‘obliteration’ and mimicry) occurs much more pronouncedly among lepidopterous larvæ, which we shall describe in a later chapter. In the case of the little green snake, the intrusion of the semi-mimetic effect is due to his complete lack of markings. Any markings, superimposed on so perfect a counter shading, would almost infallibly look as if they belonged to the background, thus clinching the *obliteration*. But simple, immaculate coloration, with full obliterative shading, is very common among snakes. In fact, it is about the commonest, as it is the simplest, type of ophidian coloration, both among terrestrial and arboreal species. Most of the snakes thus colored are swift and active kinds that seek and chase their prey instead of lying in wait for it. The gliding motion of their long, slim bodies would often be revealed by markings, in cases where without them it might pass

unnoticed. This is true especially of *transverse* marks. *Lengthwise* marks, as has been explained in an earlier chapter, are much less conspicuous on a moving object than those in any degree transverse. Stripes running the whole length of the body, such as are worn by certain snakes, add nothing to the conspicuousness of motion,* and in fact tend to lessen it, inasmuch as they split their wearers' forms, so to speak, into narrow, parallel lines of different colors or shades, some of which are likely to match the moving reptiles' backgrounds. Markings of this kind also, are, I believe, almost wholly confined to swift hunting-snakes. On the other hand, although some snakes by no means sluggish are transversely ringed (e. g., some of the coral snakes), yet markings of this type characteristically belong to species which spend most of their time at rest, and often or habitually lie in wait for their prey. Such markings, indeed, are as particularly well fitted to conceal a motionless snake as they are ill fitted to lessen the conspicuousness of one in motion. For, aided by background-marks of like aspect and direction, they 'cut up' the motionless snake's long form into short, un-snake-like segments. Lengthwise stripes, under the same conditions, have merely the effect of 'splitting' their wearer's form into several narrow but snake-like parts. So also many of the lizards that persistently "lie close" have bold, *transversely* 'secant' bands. Such are most of the iguanas, and a great many smaller species, both arboreal and terrestrial. Even the 'oilcloth'-plaided pattern of the sluggish Gila Monster (*Heloderma*) is transverse rather than longitudinal. More or less transverse also, though minutely varied and elaborated, are the beautiful and terribly effective ground-picturing patterns of such sedentary poisonous snakes as the Rattlers and the Copperhead (*Crotalus* and *Trigonocephalus*). (See Fig. 123.) The Copperhead's pattern is especially remarkable. As the reader will see by looking at Plate XI, it pictures with astounding accuracy heaped dead leaves, with their lights and shadows. This wonderful resemblance, like the rest, owes its power primarily to the underlying or inwoven counter gradation of shades, whereby the snake's cylindrical solid form is visually 'flattened out,' and prepared for complete

* (i. e., of longitudinal motion)—A. H. T.

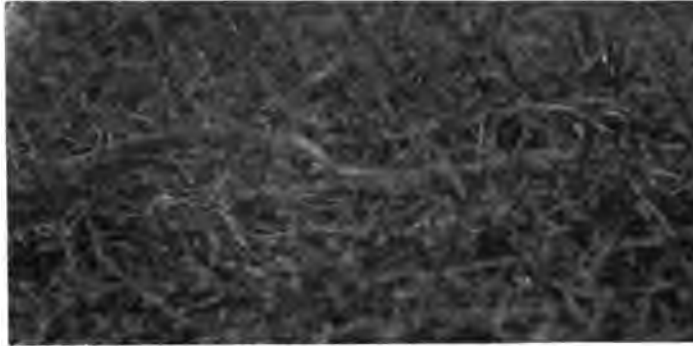


FIG. 121.



FIG. 122.

FIGS. 121-122. Green Snake (*Liopeltis vernalis*), right-side-up (Fig. 121), and up-side-down (Fig. 122). (The normally placed one—Fig. 121—however, is very poorly lighted for 'obliteration'.)



FIG. 123. The surroundings of this Rattlesnake have been made wholly by copying the snake's own color-'values,'—by perceiving what scene he represents, and using each one of his 'notes' for the right detail of the scene. The result is an astonishingly true rendering of the stones he frequents. This picture, like several others in the book, shows that animals' normal environments may be exactly deciphered from their coloration.

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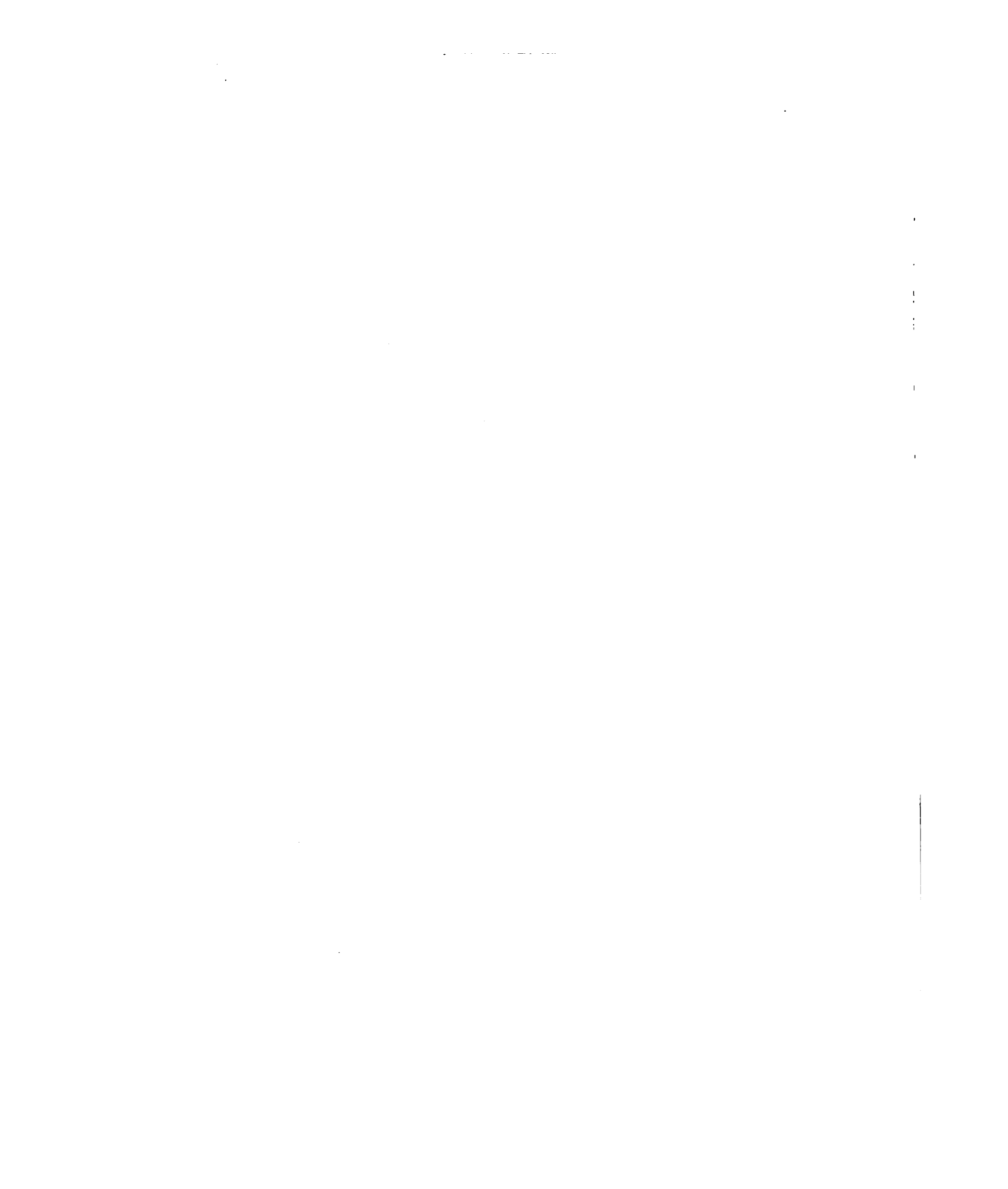
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obliteration by means of background pictures. There are many other types of ground-picturing pattern, more or less elaborately developed, among terrestrial sedentary snakes. That of the loathsome and beautiful African Puff Adder (*Crotho arietans*) is a good example of the desert type, which numbers many species, both of snakes and lizards. The Puff Adder, and all of his kindred which bear equally minute sand-pictures, are to the highest imaginable degree fitted for "lying close"—more so, perhaps, even than such a wonder as the Copperhead. *Lizards'* picture-patterns do not often reach quite such minute finish, and this is in keeping with the fact that almost all lizards are quick and agile. Most kinds, though they may "lie close," are yet always ready to resort to sudden and swift dashes in case of pressing danger; and they often catch their prey by long leaps or even running chases. The picture-patterns of lizards accordingly tend to be more generalized and crude than those of snakes, but there are of course many exceptions on both sides. Some tree-bark patterns of arboreal lizards, for instance, are perhaps as highly specialized as any snakes' patterns. (See Fig. 124.) Lizards, furthermore, have in many cases the wonderful power of sudden color-change, or 'chameleonism,' which is, I believe, wholly wanting among snakes. This phenomenon, mentioned in the last chapter, is too well known to need detailed comment here. Suffice it to say that the various adaptive costumes which the lizards assume and doff are practically all and always equipped with full oblitative shading, and often with highly-wrought background-pictures. (See Appendix A.)

One more type of marking among snakes calls for especial mention. That is the sylvan sun-and-shadow or 'leaf-checker'* pattern worn by some of the big tree-boas and pythons. This type of pattern and its uses have already been described at some length in Chapter XXI, in connection with leopards, giraffes, etc. On snakes its form is somewhat different, as the reader will see by an examination of the bits of boa pattern shown in Fig. 120, but the general effect is much the same. Indeed, the resemblance in pattern between some of these bits of boa and some of ocelot (Fig. 120), is close.

* (and hole-picturing)—A. H. T.

Mimicry, in the sense of the counterfeiting of single inanimate things, seems to play but a very small part in the coloration of snakes and lizards, whose disguising costumes are almost always *obliterative*, purely and simply. In fact, we do not know any positive cases of such mimetic equipment among reptiles, beyond the fragmentary sort mentioned in connection with the Green Snake.

Crocodylians—that is to say, crocodiles, alligators, and gavials—have not very highly specialized protective coloration. Mud-colored, armored, and unmarked,—comparatively speaking—they yet have counter shading, which tends to ‘obliterate’ them, in the water and on land. Often, however, they are so placed as not to be ‘obliterated,’ but plainly to show their great, hulking forms. Then their irregular, lumpy outlines often serve to make them pass for logs or stones. Unquestionably, they often present, either wholly or in part, a mimetic resemblance to such objects. An alligator swimming or resting at the surface shows above water only his snout, his eyes, and sometimes a portion of his back—three or four gray-brown lumps which look, to any but the most experienced eye, like points of rock, or projections of a submerged log—or cypress “knees.” However casual, all such resemblances must be of service to the alligator.* Such an animal’s more or less mimetic likeness to his inanimate surroundings is often increased by the sticking to his heavy, muddy back and sides, when they are out of water, of bits of vegetable rubbish. This is the case also with some of the great fresh-water tortoises, whose concealing-coloration is at least as simple as the crocodylians. These tortoises even have algæ and various mosslike, lowly water-plants growing on their shells, and some have dermal appendages which look like such plant-growths. For the rest, they are obliteratively shaded, and more or less mud-colored. The gigantic land tortoises, such as those of the Galapagos Islands, have even less to show in the way of protective coloration. With no oblitative shading worth mentioning, and no markings, they wear, it would seem, merely the simple, organic colors of old, weather-beaten shells and wrinkled hides. Fruit-

* In furtherance of *offensive* operations. For the brutes are the kings of the waters they inhabit, and have—at least when they are full grown—scarcely any predaceous enemies.

eating, huge, slow, mild, and immune from enemies, they have, apparently, little need of adaptive coloration of any sort. The *sea* turtles, some of them of almost equally great size, have decided obliterative shading, and sometimes—particularly on their upper shell or “carapace”—obliterative patterns. The Hawksbill (“tortoise-shell”) Turtle (*Eretmochelys imbricata*), for instance, has, as everyone knows, a beautifully marbled carapace. This pattern is obliterative, being, no doubt, a generalized sea-ground-picturing pattern, like that of many fishes, crabs, etc. Kindred patterns of the carapace are worn by certain small fresh-water and land tortoises—such as the “box turtle” (*Cistudo carolina*), of eastern North America. Two small fresh-water tortoises of the same region are particularly notable for bright color and clear pattern, namely, the common “mud turtle” or Painted Tortoise (*Chrysemys picta*), and the little yellow-spotted brook tortoise (*Clemmys guttata*). The Painted Tortoise has complete obliterative shading of shell, head, legs, and tail, and, in addition, beautiful obliterative markings on almost all his exposed skin, and on his carapace, especially along its edge. Those on the top of the blackish carapace are olive green, and narrow—mere ‘marginal bands,’ bordering the plates—the rest are red and yellow, in the forms of spots and broad streaks, on a dusky ground. These brighter markings look like bits of rich-colored water weeds, above or below the surface, like certain water and marsh flowers, like sun-flecks on the muddy bottom, and like various other common details of pond and stream scenes. (Compare the bill-colors of the Wood Duck, described and pictured in Chapter XI.) In conjunction with the obliterative shading, and the general effect of dark water and mud-color achieved by the head, legs, tails, etc., on which they occur, these bright markings must often admirably serve as obliterative picture-patterns. The under-shell or “plastron” of this turtle is immaculate light yellow-buff, while a connecting shade between it and the dusky carapace is furnished by the red-marked side-band of shell, and the similarly colored down-turned edge of the carapace itself. The little brook tortoise (*Clemmys guttata*) has the same general type of coloration, with many minor differences. Its bright

markings are all yellow, and mainly in the form of smallish circular spots, which are scattered over the whole black carapace as well as over the fleshy parts. On the head and neck and fore-legs some of them are lengthened out into streaks. The plastron is buff-colored, but marked with big, irregular black blotches—a pattern and coloration highly characteristic of the small American tortoises. The oblitative effect of the circular bright-yellow spots is much the same as that of the Painted Tortoise's richer pattern; but the little yellow disks are more aptly suggestive of spots of sunlight on dim brook-bottoms.

To sum up the foregoing fragmentary account of chelonian coloration: Most turtles, aquatic and terrestrial, are obliteratively shaded, and, in a general way, obliteratively colored; but comparatively few of them have highly specialized oblitative picture-patterns.

We now come to *Amphibians*, the last of the vertebrate classes we have to consider. These, unlike tortoises, are for the most part soft, weak-skinned animals, living much exposed to danger, and being much preyed on by rapacious creatures. Accordingly, their disguising coloration has been highly and variously developed. Most variously, indeed, as their habits are extremely various; yet the principles we have already studied cover all the variations. In their larval state, as "polliwogs," "tadpoles," etc., these animals are all more or less fish-like, both in habits and appearance, and their oblitative coloration does not then differ essentially from that of certain mud fishes (Chapter XXIII, p. 169). But in the perfect state the various types become highly differentiated both from other animals and from one another. How many and diverse, for instance, especially as regards disguising-coloration, are the types of frog and toad! Even if we confine ourselves to those of temperate North America and Europe (as we, personally, are obliged to do, because of our ignorance of the no doubt far more diversely specialized tropical forms), the essentially different types are many. First, there are the aquatic frogs, as the common Green Frog and the great Bullfrog of North America (*Rana clamitans* and *R. catesbiana*), etc. Then the terrestrial woodland frogs (*Rana sylvatica*, etc.), colored like some delicate forest ground-

bird; then the semi-terrestrial grass-haunting frogs (*Rana palustris*, *Rana virescens*, etc.). Then, again, the terrestrial toads, aquatic only during the breeding season, and otherwise fitted for life on and under comparatively dry and open ground; then the little, tight-folding tree toads (*Hyla*, etc.), modified both in form and color for concealment on perpendicular reed-stems, on sticks and twigs, or on tree trunks and on rocks, as the case may be. The Common Tree Toad (*Hyla versicolor*) of eastern North America, is a good type of this remarkable group. It is a tree-bark hunter, veritably moth-like in the exquisite minuteness and accuracy of its tree-bark pattern, and gifted in a high degree—as many amphibians are in less degrees—with ‘chameleonic’ powers of rapid color-change.

Different as are the various batrachian types above named, both in habits and in superficial aspect, they all have much in common even in their coloration. For they are all obliteratively shaded, delicately and fully, and the concealment of all of them depends primarily on this same great principle. Those which cling to tree trunks are, of course, lighted as are woodpeckers and other scansorial birds (Chapter VIII)—that is, almost like the ground animals—and hence are similarly counter shaded. The little reed-toads and twig-toads, folded up tight and smooth and narrow, and clinging close to the tree-branch or reed-stem, are likewise ‘blended into’ the surface of their perch by aid of their oblitative shading. But of course this is the case only when they are seen in back view. In profile, they may still be and often are ‘obliterated,’ being indistinguishable from whatever forms their background; but their lack of markings (a trait characteristic of some kinds, particularly green ones) hinders this effect, and must often cause their contours, thus relieving, to be visible. Here *mimicry* comes into play; for their bodies are so modified in form, and held in such positions, as readily to pass for mere slight excrescences of the plant-surfaces on which they are sitting. There may even be species whose whole disguising equipment is thus *mimetic*, to the exclusion of oblitative shading. But, with or without these possible few exceptions, the protective coloration of batrachians is preëm-

heavy obliteration, the case of all the other vertebrate orders we have considered.

Most beautiful and minute, as I have said, is the picturing of lichen-flecked bark on the backs of the obliteratively shaded and 'chameleon' tree toads e. g., *Hyla versicolor*. Equally effective and more remarkable is the picture-pattern of some grass-frogs. This pattern is closely akin not only to the grass-patterns of certain birds (see for instance the ptarmigan in Fig. 41, Chapter VII), but to that worn by some ground-perching moths, which will be described in a later chapter. It pictures dim grassy ground-shadow overlaid with crisscrossing bright-green grass blades. The picture, moreover, is one of unusual deceptive power—as everybody will agree who has tried to catch these frogs amidst luxuriant grasses. Though the species is of course not wholly confined to such grassy spots, its coloration fits them far more closely than it fits any other sort of ground. As is almost needless to say, oblitative shading is here, as in all kindred cases, the basis of the oblitative effect. The more aquatic and mud-haunting frogs have perhaps less highly specialized, but doubtless perfectly adapted oblitative coloration. The greens and browns of shore-weeds, of still, stagnant water, of water reflecting the green shore, of mud and sticks and water-soaked dead leaves—such are the prevailing colors of these frogs. These tints are arranged, moreover, in a system of complete oblitative shading, culminating usually in yellowish white on throat and belly. The independent patterns they form are more or less obscurely-mottled, but adequately serve as generalized pictures of the frogs' rather various muddy and watery backgrounds. Dull black shadow-color is an important factor in these patterns. But neither water-shine flecks of the brighter sort, nor bright brook-bottom sun-flecks occur in them, so far as I know. Somewhat more specialized, again, is the picturing of the leafy forest floor on certain woodland frogs, such as the pretty little *Rana sylvatica*, already mentioned. (See Figs. 125-126.) Small as this frog is, he yet wears two or three fairly definite leaf-edge-against-shadow pictures, on his delicate pearl-brown and dusky, obliteratively shaded



FIG. 124. Brown Lizard (Kentucky) on the trunk of an apple tree.
 Photographed from life by George C. Embody.



FIG. 127. Common Garden Spider on its web. Obliterative patterns and obscure gray head, with a glaucous web-trail made to match it.
 Photographed from life by Dr. R. W. Shufeldt.



FIGS. 125-126. Brown Wood-Frog among dead leaves and pine needles. Delicately-detailed leaf-picturing pattern, based on perfect countershading. (Notice the shadow-picture on the frog's cheek below the eye, bordered on its lower side by a sharp light streak, which in its turn has a narrow inferior dark border, and perfectly represents a leaf-stem, pine needle, or sharp leaf-edge, with its shadow.)
 Photographed from life,

but in their disguising-coloration, which presents few or no new or particularly noteworthy features. They are almost all obliteratively shaded, and wear colors and markings which tend to make them invisible against their normal backgrounds; but few of them show a very high development of special adaptive coloration. Some terrestrial kinds, living in rotten logs and stumps and beneath dead leaves, are extremely gaudy—wearing much bright blue, green, purple, or sometimes red. But if we learned more about their habits, we should probably discover some remarkable protective use of these bright colors. They are usually brightest on the tail—sometimes confined to it—and this suggests that they may serve the salamanders in the same way that the banded tails of pheasants, etc., evidently serve these birds (see Chapter XVII)—that is, as *baits* or *targets*, to make their enemies strike behind (when they are running) and miss the vital parts. This supposition is in fact extremely plausible, inasmuch as the tails of such amphibians, like those of many lizards, are easily detachable, at any point, and are often left writhing in the grasp of enemies, while the vital fore-parts to which they belonged escape. Other terrestrial salamanders are marked with brown and brownish red—dead-leaf and rotten-wood tints—and with dusky shadow-tones, in lengthwise ‘secant’ stripes. Others have transversely secant markings, and some are rather brightly pied with black and whitish, or yellow. Others, again, are marked with neat, circular spots of yellow, on a black ground, like the little tortoise described on page 177, but with the spots proportionately much larger. We, personally, know too little about the habits of these various species to speak with confidence about the special adaptive fitness of their markings. The coloration of the *aquatic* species corresponds more or less closely to that of fishes. Some have pronounced oblitative patterns, picturing mottled pond-bottoms, etc.; but the disguising coloration of many of them is very obscure.

We have now finished our skimming survey of *vertebrates*. The remaining three chapters will deal with crawling and flying invertebrate creatures.



elution.
The first peak, appearing at 10.5 min, is identified as the dimeric form of the polymer.

Fig. 1. GPC chromatogram of the polymer.

Fig. 1. GPC CHROMATOGRAM OF THE POLYMER.

CA Fig. 11
The first peak, appearing at 10.5 min, is identified as the dimeric form of the polymer.

Fig. 2. GPC chromatogram of the polymer.

Fig. 2. GPC CHROMATOGRAM OF THE POLYMER.

As shown in Fig. 1, the main peak is at 10.5 min, which is identified as the dimeric form of the polymer.

Fig. 3. GPC chromatogram of the polymer.

Fig. 3. GPC CHROMATOGRAM OF THE POLYMER.

The first peak, appearing at 10.5 min, is identified as the dimeric form of the polymer.

Fig. 4. GPC chromatogram of the polymer.

Fig. 4. GPC CHROMATOGRAM OF THE POLYMER.

FIG. A. LUNA CATERPILLAR IN POSITION

Painted from life by Gerald H. Thayer

Luna Caterpillar among leaves, in the normal position relative to the light,—'obliterated.'

FIG. C. SPHINX CATERPILLAR IN POSITION

Painted from life by Gerald H. Thayer. (Leaves, E. B. T.)

Sphinx Caterpillar in characteristic position, 'obliterated' by its illumination, having the flat aspect, color, and pattern of leaves. Cf. Fig. D.

FIG. B. LUNA CATERPILLAR INVERTED

Painted from life by Louis A. Fuertes

Luna Caterpillar among leaves, but *inverted*, so that the light strikes its light back instead of its dark belly, thus making it conspicuous.

FIG. D. SPHINX CATERPILLAR INVERTED

Painted from life by Gerald H. Thayer. (Leaves, M. E. and E. B. T.)

Sphinx Caterpillar *inverted*, so that the light strikes its bright back, making it conspicuous.

CHAPTER XXV

CATERPILLARS

THIS is an immensely interesting branch of the subject.* The existence of most naked lepidopterous larvæ is singularly dependent on protective coloration, owing to the fact that they are the favorite prey of many kinds of birds, and, living exposed to view on leaves, are also incapable of rapid motion. This universality of the extreme need of concealing coloration among hairless, leaf-eating larvæ, and the enormous number of their species, whose many and diverse food plants, feeding habits, sizes, and fundamental structural shapes call for an almost equally great variety of devices for the achievement of their protection, makes the study of them peculiarly fruitful, as well as intricate and difficult. Indeed, the subject is so vast, that no one, even if he devoted years exclusively to it, could hope to discover and appreciate more than a small fraction of the whole number of diverse but equally fine and remarkable protective-coloration developments of the larvæ of a single wooded region.

In the plates which follow, we show merely the pick of a small collection of paintings and sketches made during two autumns largely devoted to the study of caterpillars (and spiders), chiefly in southwestern New Hampshire, U. S. A. Few and imperfect though they are, they yet illustrate fairly well several principles which are of primary importance. We have confined ourselves almost entirely to hairless larvæ, because highly specialized protective coloration plays a much larger part among them than among the hairy ones. This is

* (Historically, it is especially noteworthy as being the branch in which Prof. Edward B. Poulton, of Oxford University, made his independent and earlier partial discovery of the law of Obliterative Shading. At the time, however, he did not realize that the law had a wide application, even among lepidopterous larvæ, and his subsequent original investigations of protective coloration have been largely in the field of mimicry. See, however, the quotation from *Nature* at the close of our first chapter.)

most natural, as naked larvæ are far more acceptable to most insect-eating birds, and the very hairy ones are to a large degree protected by their hairs alone, and have much less need of deceptive coloration. (It should be noticed, however, that, whether by coincidence or not, certain hairy larvæ bear a strong mimetic resemblance to details of their environment. Thus some of the furry, white or yellowish grass-caterpillars look wonderfully like the fuzzy flower-heads of the grass on which they feed, or of other species of grass sure to be common in the same field.)

The same great fundamental principle of protective coloration, which is the essential root of the matter in the case of the vertebrate orders we have been considering, namely the principle of *obliterative shading*, holds, to a very large extent, among lepidopterous larvæ. But here again we must sharply draw the line between *mimicry* and *obliterative coloration*, because the former, which has played so small a part in the orders we have already considered, is among caterpillars both common and highly developed, almost outweighing in importance the other principle, with which it is in many cases intricately combined and interwoven. *Mimicry*, then, does not attempt to render a creature invisible as an actual, well-defined object, but causes him to appear, either wholly or in part, to be something else than what he really is. The resemblance of edible or harmless to inedible or noxious creatures for defensive, and to some degree the reverse for offensive purposes, constitutes one of the simplest and most generally recognized forms of mimicry, and one to which naturalists have given much attention. Another sort, more to our present purpose, consists in the resemblance of the unobliterated forms of single creatures to single well-defined details of their natural environment. This last principle is sometimes, notably in the case of certain caterpillars, altered and elaborated into what may be called *compound mimicry*. This consists in the imitation, by the surface-aspect of a single creature or part of a creature, of *more than one absolute detail of the environment*,—which details, owing to their lack of an underlying obliterative shading, still appear to occupy exactly the position of the actual creature. The principles of *obliterative* coloration, on

the other hand, work together to render the creature's actual surface unrecognizable as the surface of any object or objects of the immediate foreground, causing it to pass for *an empty space through which the background is seen*.

Not being entomologists, we know little or nothing about these larvæ from the standpoint of nomenclature and scientific classification. We have taken them as we found them, valued them according to our recognition of their various devices of protective coloration, and classified them, for our own particular purpose, according to these devices. In most cases we do not know more than one stage of a caterpillar, and it is possible or even probable that younger (or older) stages of almost any one of our most interesting specimens may be totally different. Our point has been merely to recognize wonderful cases of protective coloration, and to take them as they stand, for what they are worth.

Beginning with the large green larvæ, such as those of the Luna and Polyphemus moths, which are disguised purely and simply by counter shading and background-color, aided by a slightly 'mimetic' system of leaf-vein markings and leaf-edge contour, we will trace the gradation of types to the caterpillars whose astoundingly effective disguises are purely mimetic. Such for instance are the larger gray, green, and brown twig-mimicking *Geometra*. These larvæ, being furnished with bodies whose general shape, color, minute surface-formation, and markings are copied perfectly from the twigs among which they feed,—some of them with forked heads which are exact facsimiles of the buds at the tips of many of these twigs, and others with heads which simulate the truncated ends of *dead* twigs,—complete the deception by clinging to a stem or branch by the back pair of legs alone, and standing out stiff and straight, absolutely motionless for minutes at a time. But true mimicry in almost all its forms has already been largely and appreciatively studied and described by several naturalists, and we shall therefore devote little more space to it than is necessary to establish clearly in the reader's mind its relation to the other systems of protective coloration among caterpillars.

Class I. Simple obliterative shading and leaf-color, usually aided by leaf-

vein markings and leaf-like contour. This class includes most of the very large green caterpillars, such as those of the Cecropia, Polyphemus, Luna and Promethea moths, many of the Sphinxes, and, with modifications, the larva of *Basilona imperialis*, etc. Most caterpillars protected by this counter shading hang upside down, and are therefore, of course, *dark* on the *belly* and *light* on the *back*, exactly the reverse of creatures which stand back-uppermost. (A few larvæ—some *Sphingidæ* among the number—rest on the *upper* sides of twigs, and are counter shaded accordingly, from dark on the back to light on the belly, exactly like birds and beasts.)

Plate XII, Fig. A, shows a Luna caterpillar in a natural position, a good example of the full working of fully developed counter shading. By this device the larva, hanging in proper position among leaves, is enabled to lack all appearance of solidity, and to 'melt' perfectly into the general, indeterminate green of the mass of foliage which surrounds it. In addition to this purely obliterative device, the caterpillar is furnished with leaf-vein-like bands and a leaf-edge-like back-contour, so that if the eye of an enemy happens to detect its surface as that of a distinct object separate from the general green, the larva may still, by virtue of its perfect flatness of tone, greatly aided by these leaf-like markings, merely pass for a flat leaf, or part of such a leaf. Without these markings to further the deception, and to distract the observer's attention from the larva's surface-texture, this, closely though it resembles that of leaves, would often betray the creature, by its slight peculiarities of appearance. These markings bring in an element of *mimicry*, inasmuch as they help the larva, when he is revealed as a definite object, to pass for a leaf or leaf-portion no more distant than he actually is from the observer, rather than picturing the background upon him. This is proved by the back-contour, which seems to mimic the wavy edge of a single, foreground leaf, with its serrations of full size, rather than reduced by distance; and the vein markings also are in keeping with this plan, being pronounced and large. Many, in fact nearly all, of our large green caterpillars have this form of protective coloration, and the Luna is chosen merely as one good type of the class. There are many fine examples of it

among Sphinx larvæ, which often have the leaf-vein markings exaggeratedly developed. The Polyphemus caterpillar, which closely resembles the Luna, largely lacks these markings, but has an even more leaf-like contour.* There are few creatures in all nature better obliterated by shade-, color-, and pattern-devices than are many of these large green caterpillars, which are doubtless much sought after by certain birds, as for instance the Broad-winged Hawk (*Buteo platypterus*). A human eye needs much training to be able often to detect a Luna or Polyphemus caterpillar hanging amidst foliage. Fig. B shows the same Luna caterpillar with the back uppermost, the reverse of the normal position. It will be evident to any eyes that the creature thus placed, so that the proper effect of its light-and-shade gradation is exactly and doubly thwarted, is extremely conspicuous, and that neither its leaf-green color, nor its leaf-like markings and contour, both so extremely useful when coöperating with the proper effect of the fundamental light-and-shade-effacing principle, can now avail it. The creature is now staringly revealed as a fat green larva, light on the back and dark with shadow below,—as even *monochrome* solid objects are plainly revealed to the eye. Figs. C and D are two Sphinx-caterpillar pictures exactly corresponding to those of the Luna, as will be seen. Fig. C shows the larva *in situ*, Fig. D *reversed*. An interesting modification of this scheme is found in the caterpillar of *Basilona imperialis*, the Imperial Walnut Moth. Lacking distinct leaf-markings, it is furnished with scattered, long, light-colored hairs, which, when it is seen from a slight distance, completely blur its surface, and greatly help its rough but adequately 'obliterated' green body to blend with the general green of its foliage-background.†

* The red warts, with a pearly luster, of which we have made no mention, and which are common to both species, are larger and brighter in the Polyphemus. Whatever may be their other uses, they lessen the larva's visibility, inasmuch as the tiny spots of gleaming light upon their tips suggest to the eye the glinting of light through holes in the leaves. The huge and gorgeous warts of the *Cecropia* caterpillar are not lustrous, and cannot serve this purpose, but they closely resemble disease-excrecences upon leaves, and may well be strictly disguising devices. Or they may be also fixed defensive weapons, serving to make the larva unpalatable, as the branching bristles of the *Automeris io* caterpillar certainly serve to make it *dangerous*, to a would-be devourer.

† With us these caterpillars feed chiefly on red maple and white pine, and those of the bluish

• *Class II. Counter-shaded Leaf-edge Caterpillars.* The members of this class are protected by an exquisitely delicate coöperation of *obliterative shading* with minutely accurate flat-surface mimicry, and this system is variously modified in different branches of the class. But this new principle must be more exactly defined. *By coöperation of mimicry with obliterative shading*, we mean a resultant mimetic resemblance achieved throughout on a basis of counter shading. Whereas pure mimicry is a matter of the actual form and surface-coloration of animals, irrespective of any artifice of light-and-shade, the mimetic resemblance to a flat leaf-edge in the case of these larvæ is achieved by the aid of a delicate system of counter shading. That is, the elaborate *single-leaf pattern* worn by them looks perfect only when they are so lighted as to bring their whole counter-shaded body to an appearance of perfect flatness; or in other words, their superadded pattern as well as their general surface-color is obliteratively shaded to counteract the effects of the normal high-light and shadow. The markings are lighter, brighter, and sharper in proportion as they are situated on parts of the creature which are normally more averted from the light, and *vice versa*. (The oak-leaf larva shown in Fig. N is a good example of pure and simple leaf mimicry, as opposed to *leaf mimicry dependent on counter shading*.) This composite scheme might seem to belong rather to *obliterative coloration* than to *mimicry*, but we must call it a form of *mimicry*, for the reason that the resultant resemblance is to part of a definite object green pine foliage are almost always of a much more bluish green than those which feed on maple.

Another interesting example of pigmentation perhaps directly affected by diet is that of the change from green to red undergone by many of the large caterpillars in the autumn, shortly before their transformation into chrysalids, and at precisely the season when many of their food-leaves are turning red. Not only the spinning-caterpillars, such as the Luna and Polyphemus, but also certain of the *silkless* ones, notably the *Basilona imperialis* just mentioned, often turn tawny, reddish, or almost bright red, or become strongly tinged with such colors, shortly before they stop feeding, in the late summer or autumn, when they have attained their full size. Thus it cannot be merely a matter of silk-development in their bodies; and it is further noteworthy that the specimens of *B. imperialis* which develop on pine or spruce trees (spruce is occasionally eaten) rarely or never turn wholly red, while their neighbors of the maple trees are often of a rich copper color, or even brighter, when they descend the trunks to enter the earth.

EXPLANATION OF PLATE XIII

FIG. E. LARGER-SPOTTED
BEECH-LEAF-EDGE CATERPIL-
LAR IN POSITION, passing for a part
of the leaf on which it is feeding.

FIG. F. SMALLER-SPOTTED
BEECH-LEAF-EDGE CATERPIL-
LAR IN POSITION. Cf. Fig. E.

FIG. G. LARGER-SPOTTED
BEECH-LEAF-EDGE CATERPIL-
LAR, DETACHED, INVERTED.

FIG. H. SMALLER-SPOTTED
BEECH-LEAF-EDGE CATERPIL-
LAR, DETACHED, INVERTED.

FIG. I. WHITE-BIRCH-LEAF-
EDGE CATERPILLAR IN POSI-
TION, passing for a continuation of
the leaf on which it is feeding.

FIG. J. WHITE-BIRCH-LEAF-
EDGE CATERPILLAR, DETACHED,
BACK-VIEW. Cf. Figs. E—H.

FIG. K. JAGGED-LEAF-EDGE
(ELM?) CATERPILLAR IN POSI-
TION.

FIG. L. JAGGED-LEAF-EDGE
CATERPILLAR INVERTED. (The
direct sky-light making leaves and
caterpillar bluer.)

FIG. 1. SMALLER-SPOTTED
BIRCH-LEAF-BIDGE CATERPIL-
LAR IN POSITION. (PLATE E)

FIG. 2. LARGER-SPOTTED
BIRCH-LEAF-BIDGE CATERPIL-
LAR IN POSITION. (Passing for a part
of the leaf on which it is feeding.)

FIG. 3. SMALLER-SPOTTED
BIRCH-LEAF-BIDGE CATERPIL-
LAR, DETACHED, INVERTED.

FIG. 4. LARGER-SPOTTED
BIRCH-LEAF-BIDGE CATERPIL-
LAR, DETACHED, INVERTED.

FIG. 5. WHITE-BIRCH-LEAF-
BIDGE CATERPILLAR, DETACHED,
BACK-VIEW. (PLATE E-II)

FIG. 6. WHITE-BIRCH-LEAF-
BIDGE CATERPILLAR IN POSI-
TION, passing for a continuation of
the leaf on which it is feeding.

FIG. 7. LOGGED-LEAF-BIDGE
CATERPILLAR INVERTED. (The
direct sky-light marking leaves and
caterpillar dim.)

FIG. 8. LOGGED-LEAF-BIDGE
CATERPILLAR IN POSI-
TION.



E



F



G



H



I



J



K



L

in the actual position of the counter-shaded creature, rather than to its background. With this explanation we can proceed to a more particular description of these wonderful larvæ. They feed, and, unlike most caterpillars, *rest*, on the edges of leaves, and as their weight always draws downward the edge to which they are clinging, they are to some degree caterpillars of the upside-down habit, and accordingly must have, in order that their appearance of solidity shall be effaced, an inverted oblitative gradation of light-and-shade. Unlike the larger counter-shaded caterpillars, such as the Luna, which cling to *stems* far in among the foliage, they are usually fully exposed to view, on the edges of outside leaves, and hence it is imperative that their surface, perfectly flattened in appearance, should imitate as closely as possible the leaf-texture. The degree to which this is achieved is one of the most exquisite and wonderful things in the whole field of protective coloration. No caterpillar is harder to detect, at the closest range, than is one of these beautiful leaf-edge larvæ in its natural position. The minute reticulate markings of the healthy leaf-surface are closely copied on the larva's counter-shaded body by small dark flecks, and, in addition, he often wears facsimile pictures (rendered perfect by the same process of counter shading) of leaf-disease-spots. These spots, and even the general coloring, vary somewhat in size and shape, but always within limits beyond which the disguise would begin to be impaired. We have seen many such caterpillars, representing several species and probably several mere varieties. As a rule, it seems to be true that one kind of tree harbors only one kind of 'leaf-edge' larva, which is almost or quite peculiar to it, and rarely to be found on any other plant. In the case of the beech, however, which feeds a greater variety of particularly interesting 'disguised' larvæ than any other tree we know, we have found three quite distinct species of the leaf-edge class infesting it, and one of them, whose coloration is less distinctive than that of most, is pretty often found on other trees. Again, the form inhabiting certain kinds of maple, and wearing the deep-red spots of diseased maple trees, occurs also on witch-hazel, and its spots are then usually browner and smaller.*

* Possibly we are here speaking of two species.

Plate XIII, Fig. E, shows the larger-spotted species of beech leaf-edge larva, in its normal position. Fig. F shows the smaller-spotted species in position. Figs. G and H show these two larvæ inverted, against a black background. Figs. I and J are two sketches of a white-birch leaf-edge larva, I being the creature *in situ*, and J a simple back view. Of this larva we have seen only two specimens. It is but slightly shaded from dark to light, and either lives usually very far in among the leaves, where the light is diffuse, or else, because it feeds on rather stiff leaves, whose edges are but slightly pulled downward by its weight, can make little use of counter shading. The light spots on this caterpillar closely picture the small, transparent worm-scars so common on the leaves of the white birch.

As we have said, the principles involved in the protective coloration of this group of caterpillars are variously modified. The forms just described are among the commonest and most noteworthy of those we have seen, but they lack one element of finish which is found in caterpillars of another branch of the class. Those already described have backs very slightly indented between the segments, and without humps, hence their contour can never pass for the *perfect edge* of a leaf which is in any degree serrated, as most leaves are. But as they freely mow away whole sides of leaves, and usually rest close to the stem on the mutilated edge, this is hardly a lack. They merely pass for a continuation of a gnawed and imperfect leaf-edge, in whatever position they cling, except in cases where they are so far from the stem that their backs are farther out than even the unbroken leaf-edge could be—as sometimes when they are beginning a new leaf. In such a case the smooth back-line is, momentarily, a defect. (This need hardly be taken into account, however, because it is the habit of these larvæ to work in along the midrib of a leaf, from a position on the stem, and it is only in rare cases that their backs are out beyond the line of a normal leaf-edge.) The caterpillars of the other type, of which we have as yet seen only one individual, may be called the *contour* leaf-edge larvæ, for their back-contour is formed in close imitation of the perfect, serrated edges of the leaves on which they feed. This resemblance is effected by a

series of high, double-pointed humps, one on each segment back of the front feet, and is further aided by certain markings between and on these humps. Such a caterpillar, therefore, doubtless tends to keep itself adjusted so that the line of its back continues that of the unbroken leaf-edge, from each side of the hole it has gnawed, and in which it is resting. It is also furnished with diagonal darkish lines, one on each segment, which closely resemble the parallel vein-markings on such leaves as elm and birch. Our specimen had no disease-spot representations. The gradation from dark to light (dark on the belly and light on the back, of course, because this is one of the upside-down caterpillars) is perfect, and the larva's invisibility of course depends primarily on this, as the two figures (K and L) show. Unfortunately, our only specimen was found on the ground, and we cannot be sure what its particular food plant is. The fact that elms were common close about it, as well as its beautiful resemblance to the edge of the small elm leaf on which we placed it, make it seem likely that it belongs on this tree. This caterpillar may be said to constitute a separate division of the counter-shaded leaf-edge class, which division we may define as follows:

Class II, Division A. Involves all the principles assigned to Class II (with the exception, as far as we know, of the leaf-disease-spot picturing), with the additional element of leaf-contour mimicry achieved by humped segments, and pronounced leaf-vein markings. (Fig. K shows the caterpillar in position, Fig. L inverted.)

Class II, Division B. The protective coloration of these larvæ involves the principles already assigned to Class II, coöperating with an additional distinct element of background-picturing. We have here a new and very wonderful departure from the simple leaf-edge types already described. The caterpillar shown in Plate XIV, Fig. M, a strict leaf-edge inhabitant, is, down to a certain point on its back, exquisitely counter shaded and colored to resemble the bluish-green upper surface of a beech leaf, its usual food. Its body is even furnished with minute black specks, in apparent imitation of the faintly marbled aspect of the leaf. But this graded green, fading into a pure-

white line along the sides of the back, terminates then abruptly against the smooth, deep yellow green of the back itself. Thus it appears that the perfect flat-leaf-edge color achieved by counter shading extends over part of the larva, and then suddenly gives place to an entirely contradictory and at first inexplicable stripe of dark, exactly where the culmination of paleness would normally occur. Finding the larva on the ground, one may well be puzzled, but the first sight of it normally situated on a leaf is a revelation, as our picture (Fig. M, 1) shows. The counter-shaded blue-green belly and sides represent an extension of the upper side of the leaf, the white line is an intensified representation of the line of the leaf-edge, and the sharply contrasted and deeply shadowed yellow-green back simulates perfectly the shadowed *underside* of a leaf, either the same one or one slightly more distant. If we examine the caterpillar very closely, we discover still another wonderful detail of its disguise. *The dark-green back itself is slightly counter shaded to escape all trace of a solid appearance, and to match perfectly the monochrome under surface of leaves.* A narrow yellow line runs along the middle of the back, and this serves to efface the culmination of shadow which would otherwise appear there. In the case of this *leaf-edge* larva the green back doubtless often passes for the underside of the same leaf, as shown in the picture (Fig. M, 1), but in that of certain larger caterpillars which wear a similar device, as for instance the larva of the common smaller hog-nosed woodbine caterpillar, the illusion is less exact; and as this caterpillar rests on a stem rather than a leaf-edge, even its light patch often passes for a portion of some partially concealed leaf, rather than for the continuation of a wholly exposed one.

The modifications and different adaptations of these various principles are almost unlimited, and we can only hope to give examples of a very few most highly representative and easily comprehensible forms. Fig. M gives three representations of the beech larva just described, 1 being the larva in position on the leaf-edge, 2 the same detached from the leaf, and 3 a simple back-view of the creature. These caterpillars are usually unspotted, as here shown, but are sometimes marked with brown patches closely resembling

FIG. M. UNSPOTTED BEECH-LEAF-EDGE CATERPILLAR

1. In position, part of him passing for a continuation of the leaf on which he is feeding, and part of him for the underside of the same leaf.
2. Larva detached from the leaf.
3. Ditto, back-view.

FIG. N. OAK-LEAF-EDGE CATERPILLAR

Detached.

FIGS. O and P. OAK-LEAF-EDGE CATERPILLAR

In position.

FIG. Q. CRUMPLED-AND-WITHERED-LEAF-EDGE-MIMICKING CATERPILLAR

In position, representing edge of diseased portion of leaf.

Painted from life by Gerald H. Thayer (Leaves, Figs. M. and Q., E. B. T.)

FIG. 1. POSITIONING OF THE SUBJECT

1. In position, part of him passing for a continuation of the line
2. Part of the body and part of him for the continuation of the line
3. Part of the body from the line
4. Part of the body

FIG. 2. POSITIONING OF THE SUBJECT

Position

FIG. 3. POSITIONING OF THE SUBJECT

Position

FIG. 4. POSITIONING OF THE SUBJECT

In position, representing part of the body

FIG. 5. POSITIONING OF THE SUBJECT



those common on beech leaves—much like the species shown in Fig. G. We have also seen one or two wearing almost the same general scheme of pattern, but done as to color wholly in brown,—and it happened that these were found resting on twigs or stems, instead of leaf-edges.

Class III. Purely mimetic leaf-edge larvæ. Complete leaf-edge mimicry *without obliterative shading.* The caterpillar shown in Figs. N, O, and P, although strictly a leaf-edge larva, deviates so widely from one of the main principles of that class as above defined that it must be treated separately. It lacks, namely, all trace of obliterative shading, and its beautiful, shiny, oak-leaf green, more closely like a leaf in surface-texture than is that of any of its relatives we know, is of one uniform shade and tint, so that the larva can never escape the full appearance of a solid, cylindrical body. But the perfect leaf-color and texture of its green parts, in coöperation with the marvelously minute counterfeit of the transparent, brownish worm-scars so common on oak leaves, which the remainder of its body wears, make it—when, as is its wont, it hangs *inverted* from a leaf—pass for the down-curved edge of it. The vein-pattern is minutely copied on the larva's brown parts, and between the green and the brown there is usually a narrow, irregular yellow line, exactly such as the leaf commonly has. The broken-leaf-edge aspect is further aided by the brown hump on the caterpillar's fourth segment. Altogether, though lacking light-and-shade gradation, this is one of the most wonderful of protectively colored caterpillars, and one of the very hardest to detect *in situ*. We have sometimes found this caterpillar on beech, the leaves of which have worm-scars very like those of oaks.

Class III, Division A. (Fig. Q.) *Structural and pattern mimicry of an irregularly crumpled leaf-edge* (thus approaching the scheme of the structurally mimetic larva shown in Fig. S, though the latter is not a leaf-edge inhabitant). This division includes un-counter-shaded leaf-edge caterpillars of a different type from the oak larva—those, namely, which, by color, pattern, and curiously humped backs, simulate the irregularly crumpled and withered edge of a leaf. Their bodies are almost always crossed near the head by a

band of leaf-green, which greatly furthers the deception. There are many wonderful caterpillars of this type, usually a good deal larger than the one here shown, which is the only one we have succeeded in painting.

Class IV. Partial mimicry of a detail of the normal surroundings, with a polished back which under certain conditions reflects the color of surrounding objects, combined with flat-leaf-edge counterfeiting, achieved by light-and-shade gradation. The pretty caterpillar shown in Plate XV, Fig. R (No. 1 reflecting nothing, No. 2 reflecting green, and No. 3 reflecting red), is our sole example of this class. Its light, extremely shiny back, which serves for shadow-effacement when the caterpillar hangs upside down, serves also for actual *reflection* of the color of the encompassing foliage (as in the white spider shown in Plate XVI, Figs. V-Y), while the yellow stripe down its side must usually pass for the stem of some other poplar leaf than the one on which it is feeding. The fact that this well-pictured stem must, owing to its large size, appear to be at least as near the observer as the caterpillar actually is, allies the case to partial mimicry rather than to simple obliterative coloration. When the caterpillar rests on a yellow stem, rather than a leaf-edge, as it often does, the mimetic element is still more pronounced, for then the stem which he is in fact concealing with his feet is by his yellow stripe made to appear to pass on uninterruptedly, if somewhat crookedly, and the remainder of his body merely merges with the general green which surrounds him. This larva we have found only on small-leaved poplar trees.

Class V. Complete structural mimicry of a common detail of the creature's habitual inanimate surroundings. The wonderful little caterpillar which we have chosen to typify this class bears on its back a double row of large fernlike fronds, with perfectly developed stem and branches, and when feeding or resting amidst the curled-up edges of unhealthy maple or other leaves, which it evidently mimics, is almost impossible to detect. In its elaborateness and efficiency, this disguise is among the very most wonderful. At the season when the caterpillar is to be found, most of the forest trees have many of these partially withered leaves. Wherever the creature stands on a leaf, it passes

FIG. R. 'MIRROR-BACK' CATERPILLAR

Painted from life by Gerald H. Thayer.

1. Reflecting nothing (save the sky-light).
2. Reflecting leaf-green.
3. Reflecting a red leaf.

**FIG. S.
CRUMPLED-LEAF CATERPILLAR**

Painted from life by G. H. Thayer.
(Leaf, Emma B. Thayer.)

1. In position, back-view.
2. Ditto, side-view.
3. Detached, enlarged.

**FIG. T.
CURLED-DEAD-LEAF-MIMICK-
ING SPHINX CATERPILLAR, IN
POSITION.**

Painted from life (larva and withered leaf) by Louis
A. Fuertes. (Live leaves, G. H. T.)

PROBLEMA 2

Una
partícula se mueve
en un campo
gravitatorio
uniforme.

Se pide:

1) Determinar el potencial.

2) Calcular la
energía mecánica.

3) Calcular la
energía cinética
y la energía
potencial.

4) Calcular la
energía cinética
y la energía
potencial.



for a dead and crumpled spot. The specimen here shown had lost one of the fronds from its right side. (These caterpillars are said to shed their fronds and weave them into their cocoons.) (Fig. S, Nos. 1, 2 and 3.)

Class VI. Highly developed color-and-pattern mimicry, scarcely aided by modifications of form, of a detail of the caterpillar's usual inanimate surroundings (Fig. T.). The plants on which this late-developing sphinx larva commonly feeds, bear, almost invariably, at that season, a few black dead leaves, frost-bitten or otherwise wilted—and the caterpillar, hanging head downward, is a close counterfeit of one of these. The imitation is very close indeed,—even the usual dark hole at the bottom of such a leaf being rendered by the black spot on the caterpillar's head, intensified by the encircling white,* and the vein-markings being accurately copied by diagonal stripes and fine reticulations. The tail-horn, which this larva has in common with most sphinx caterpillars, here serves to counterfeit a leaf-stem, the midrib continuation of which through the leaf is closely imitated on the caterpillar by a pronounced light line. These markings and details of form are largely the same as those found on *obliteratively shaded* sphinx larvæ, where they serve the same general purpose of leaf-stem and vein imitation; but the present case, being one of pure and simple *mimicry*, allows of a clearer and more definite development of these details. Notice this caterpillar's complete lack of light-and-shade gradation. He is equipped, not to be unapparent as a solid object, and to merge with the details of his average background, but to appear to be another kind of definite, rotund body than such as he really is.

Class VII. Compound mimicry of normal inanimate surroundings, coupled with an element of background-picturing. (Plate XVI, Fig. U.) This caterpillar's several light-colored longitudinal stripes resolve themselves into the appearance of separate needles of the white pine tuft in which it feeds. But the darker and broader green stripes (sometimes partly dark red) then pass for the general background of needles, against which the light stripes show as

* See Chapter XX, p. 125; Chapter XXII, p. 157, and Fig. 120.

separate, glistening, nearer ones. Thus the scheme departs from true mimicry and approaches obliterative coloration, as it has already departed from simple mimicry by the fact of its simulating *more than one* absolute foreground object. This is one of the uncommon and noteworthy cases where an element of *obliterative coloration* is present without obliterative shading. The caterpillar's head is marked with red and yellow, in close imitation of the scales at the bases of the needles—and it usually rests with its head against or near these scales. It is a kind of sphinx, and, as far as we know, it feeds exclusively on pine. Indeed, its mimetic resemblance to pine needles has been commented on by entomologists. In the picture, No. 1 is a back view, No. 2 a side view.

We have now, in the matter of caterpillars, reached the end of our material. The forms mentioned and figured are, as has been said, only a very few out of an enormous number. We ourselves have found many other equally noteworthy ones, which for various reasons we have failed to figure. Among the most interesting of those omitted is the caterpillar of one of the Lappet moths, which achieves in a remarkable way very simple mimicry of a slight protuberance on a thick tree *branch* (the sort of perch on which it, unlike most caterpillars, is wont to rest). Its body is much flattened, and fits closely to the branch; and it is marked, irrespective of the scattered hairs, in close imitation of the bark. There is no light-and-shade gradation, and the shadowed sides of the caterpillar, as well as the shadowed crevice which would show between it and the bark, are beautifully bridged over by an obliquely descending fringe of numerous hairs. So slight is the larva's actual surface-rotundity, indeed, that under favorable conditions it doubtless seems to merge with the flat or slightly rounded bark-surface; so that this is another caterpillar whose disguise in part achieves 'obliteration' without counter shading.

We have at least figured and described enough widely diverse caterpillar disguises to suggest the wonderful richness of this great field of study, still almost unexplored. Anyone who will devote a few late summer and early autumn days to caterpillar hunting, along wooded roadsides—finding them by

FIG. U. PINE-TUFT CATERPILLAR

Painted from life by Gerald H. Thayer.

1. Back-view.
2. Side-view.

FIGS. V, W, X, Y, PORCELAIN-WHITE SPIDER

Painted from life by Gerald H. Thayer. (Leaves, E. B. T.)

Figs. X and Y, spider suffused with green light amid foliage.



U

1

2



V



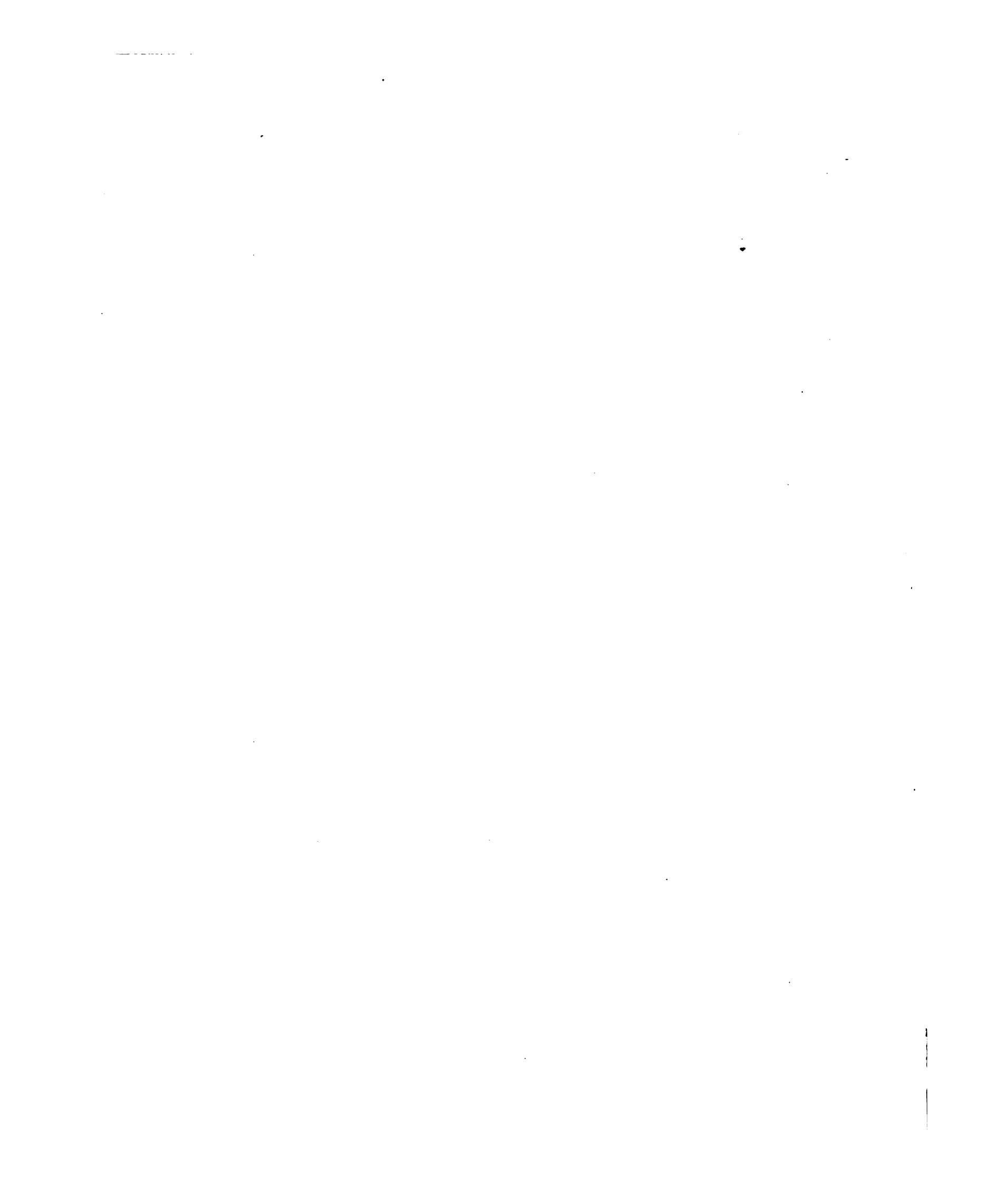
W



X



Y



the aid of their droppings on the ground, and trying always to see them in their natural positions—will not only soon be acquainted with many forms like those we have described, but will, if he has the trained artistic sight with which to recognize them, discover many new and equally wonderful cases.

CHAPTER XXVI

A GLANCE AT INSECTS OTHER THAN LEPIDOPTERA (ORTHOPTERA, COLEOPTERA, HYMENOPTERA, DIPTERA, ETC.), AND AT SPIDERS

HERE we should be totally overwhelmed by the hugeness of the subject, and foiled by our own ignorance, if we sought to give more than the slightest general sketch of the main prevailing principles. Passing by* the wonderful purely *mimetic* developments, such as those occurring among insects of the families *Mantidæ* and *Phasmidæ* (walking sticks, leaf insects, mantises that mimic flowers, etc.), which have been studied and described by many naturalists, and with many of which the world at large has long been familiar, we will confine ourselves to a rapid survey of the mass of less obviously remarkable types. Beginning with the three main families of Orthoptera (grasshoppers, locusts, and crickets) we find *obliterative shading* playing its usual important part, though in less uniformly high development than among vertebrates. Ground-perching locusts (*Acrydiidæ*) are all (?) obliteratively shaded, in full, and furnished with ground-picturing patterns, some of which are almost as minutely finished as those of Nighthawks, desert snakes, etc. Some kinds habitually perch on rocks, and have true and fine rock-patterns, much like the Nighthawk's. Others, again, resorting much to sand, and bare, dry earth, have more sandy-peppered patterns, like that of the Puff Adder. Somewhat more brightly colored, as a rule, are the many species which habitually perch on or amidst terrestrial vegetation. They are flecked and patched, banded and striped, with grass- and ground-weed tints—green, yellowish, red, olive, brown, and black, in more or less generalized picture-patterns (or sometimes more crudely 'ruptive' ones). Lo-

* As we ignore, for the present, all questions of 'live'-mimicry among these insects.

custs, as a rule, "lie close," sitting tightly folded; their fore-wings (which, with the head, sides, and legs, bear the counter shading and fine patterns) wholly hiding the broad, membranous hind-wings. These are often brightly and boldly colored, without minute patterns, and when expanded in flight, against sun-variegated backgrounds, they lessen the conspicuousness of the moving insect just as do the bold 'ruptive' markings of many butterflies (and moths). (See Chapter XXVII.) Some of them, again, must under certain conditions act as 'dazzling'-marks, by their sudden display and equally abrupt eclipse.

Among the *Locustidae* or true grasshoppers, some of the more terrestrial kinds have much the same general system of protective coloration as have the herbage-haunting *Acrydiidae* above described. For the most part, however, even these terrestrial ones are less finely patterned, having mere simple 'ruptive' patches of green and brown, or kindred colors, and the bright-background picturing above mentioned plays but a small part with them. Many of the more arboreal kinds—of which the well-known "Katydid" (*Platyphyllum concavum*) of the eastern United States is a good example, and even some of those that haunt terrestrial herbage, are disguised by leaf mimicry, for the attainment of which the whole body seems to have been modified. The pith of the resemblance, however, lies in the fore-wings, which, when folded, largely or wholly (according to the species) inclose and hide the body, and which, being of a perfect, bright leaf-green, are also marked with a leaf-like midrib and netted side-veins, so that, in profile, the insect closely simulates a narrow leaf, or portion of a leaf. But, as in the case of the leaf-edge caterpillars described in the preceding chapter, this mimetic resemblance is largely indebted to obliterative shading. Externally convex, and folded downward over a more or less cylindrical body, these fore-wings are made to look *flat* by a delicate counter shading, just as we have seen in the case of the caterpillars' bodies. When, as is the way with several species of leaf-mimicking grasshoppers, the fore-wings are comparatively narrow, so that much of the body is exposed, it is obliteratively shaded, to the full, and hence, in the right position relative to the light, it too is 'flattened,' and continues

the flat-leaf aspect of the wings. But the effect in this case is less strongly mimetic, for the body presents a less leaf-like surface than the wings, especially in its lack of venation. Indeed, some of the green grasshoppers have scarcely more than a general obliterative equipment of counter shading and foliage-color.

The next family of Orthoptera, the *Grillidæ* or crickets, have less to show in the way of disguising-costumes. Mainly nocturnal, and in many cases subterranean and fossorial, they largely lack highly developed colors and patterns. Most of them are black, blackish, or brown,—monochrome, without pronounced obliterative shading. Diurnal kinds, which stay above ground, will doubtless all prove to be obliteratively shaded, though still dull-tinted,—very few (or perhaps none) of them sharing the livelier coloration common among their relatives the locusts and grasshoppers.

The cockroaches and earwigs (*Blattidæ* and *Forficulidæ*) are likewise nocturnal—shy and seclusive haunters of dark holes—and their protective coloration amounts, apparently, to little or nothing beyond a general dull, earthy brownness of tint.

The *Coleoptera*, or beetles, in the adult state,* are, for the most part, tough, hard, and shelly, and probably less welcome food, to the majority of insect-eating animals, than are caterpillars, locusts and grasshoppers. Many of them, moreover, are equipped with rank defensive (?) stench, as well as with strong biting jaws; and many are nocturnal—skulking by day under stones, under rotten bark, or in other safe retreats. Considering beforehand all these facts, we should not expect to find beetles, as a class, particularly well provided with disguising-costumes; and they certainly are less so than some of the more 'succulent' tribes of insect. On the other hand, they are by no means immune from enemies, nor do they, in the great majority of cases, lack obliterative coloration. Few have simple obliterative shading, as few have the regular perching-habits, the habitual 'same-side-up-ness,' indispensable to the full

* Their larvæ almost all live hidden away from the daylight, and are as a rule monochrome and patternless,—often colorless.

operation of that disguise, but many are equipped with brilliant iridescent or metallic colors—green, blue, purple, bronze-red, bronze-yellow, etc.—which strongly tend to obliterate them amid and against vegetation. The fact that some nocturnal and subterranean kinds as well have rather brilliant metallic colors * merely reminds us how much is still to be learned about their habits. But it is, as far as I know, among truly diurnal species that the highest brilliancy of coloration occurs. Sometimes, as on certain tiger beetles (*Cicindelidæ*), etc., brilliant iridescence is combined with small, dull, sheenless spots, and the effect of this combination, in a proper view, is highly obliterative, particularly if the beetle is also counter shaded. Or again, iridescent brilliance, in spots or stripes, may be a small factor of a soberer pattern. Innumerable, indeed, are the variations of generalized obliterative pattern—‘secant,’ ‘ruptive,’ etc., in bands, stripes, spots and mottlings—which occur among beetles. Black, yellow-buff, reddish brown, and yellowish green are probably the commonest colors of the bolder patterns, which are strongly obliterative against most natural backgrounds, though by no means highly specialized. *Transverse* ‘secant’ marks predominate in these patterns, in accordance with the simple laws of ‘obliteration,’ already many times explained. But much more subtle patterns also occur on the *Coleoptera*, especially among those which habitually rest on the bark of trees in the daylight. Even on beetles, such finely mottled and grizzled tree-bark patterns are usually accompanied by obliterative shading, and hence are true ‘picture-patterns.’ If the counter shading were absent, the disguise would be *mimetic*, making the beetle look like an excrescence on the bark. But we do not know of any pronounced cases of this kind. Some *flower* beetles also have full and delicate obliterative shading. Of these the American Rose Chafer (*Macrodactylus subpinosus*) is a good example.

But for all their frequent obliterative patterns and rich, iridescent vegetation-colors, the *Coleoptera*, as a group, are far from taking top rank among ‘disguised’ animals, or even among disguised insects.

In the order *Hemiptera* there are relatively even fewer notable types of

* Most of them, however, are black or blackish.

disguise. *Cicadas* (*Cicadadae*) are among the largest and finest insects of this group, and their disguising-coloration, in the case of some kinds at least, is very elaborately wrought. The Common Dogday Cicada of eastern North America is the species with which we are most familiar, and it will suffice as an example of the family. The broad, plump body of this insect is obliteratively shaded, being grayish and pinkish white beneath, with some faint markings, and shading into deep blackish brown above—on the upper sides of the head, abdomen, and thorax. This brown upper side, moreover, bears a beautiful, bark-like picture-pattern, made by narrow bands of light olive-green upon the darker ground color. On the abdomen these bands are simple and transverse, on the thorax and head they are beautifully branched and netted. Though the Dogday Cicada has not strictly regular perching-habits, it is an eminently arboreal insect, and spends most of its time clinging to the bark of tree trunks and branches, in which situations both its counter shading and its mottled pattern often come fully into play. When, as is also frequently the case, it sits upon and among small twigs, either in trees or bushes, it is apt to have more varied backgrounds, and its rich but none too specially adapted oblitative pattern matches these nearly or quite as well as it does the single plane of near-bark surface.

Some at least of the larger plant bugs—such as the stinking squash-and fruit-bugs of eastern North America—are counter shaded. *Anasa tristis*, for instance, the Common Squash-bug, is blackish above and yellowish below. It lacks pronounced markings, although several of its kindred have well-developed oblitative patterns, of various kinds. Probably, on the other hand, some of them bear *mimetic* resemblances to parts of their food plants. This is certainly the case among the *Membracidae*, or Tree Hoppers. These little insects are for the most part sluggish and still, clinging close to the branches and twigs of trees, whose bark they perforate with their sharp piercers for the sake of drinking the sap, which is their sole nourishment in the adult state. When disturbed, they leap from their perch with surprising force, and fly to another resting-place. Dr. Harris (“Insects

Injurious to Vegetation," p. 222) says of one species, which inhabits the locust tree: "They never sit across the limbs, but always in the direction of their length, with the head or fore part of the body toward the extremity of the branches. On account of their peculiar form, which is that of a thick cone with a very oblique direction, their dark color [without oblitative shading], and their fixed posture while perching, they would readily be mistaken for the thorns of the tree . . ." Such mimicry of excrescences on twigs is probably common to many members of the Tree Hopper family. Some, however, have patterns which cannot well lend themselves to a simple mimetic resemblance, and whose effect must tend rather toward obliteration. The little Leaf Hoppers (*Tettigoniidae*, etc.) are often very bright-colored—green and red and yellow, in sharp, clear patterns—like tiny parrots. The effect of this motley coloration, against flower-, leaf-, and stem-surfaces, is of course oblitative—especially as the little hoppers are also counter shaded. Very likely, however, there are also definite mimetic developments among them. Plant lice or aphides (*Aphididae*) are of various tints, from dark brown and grayish black to fair, translucent green. As a rule, their color closely matches that of the plant surface on which they habitually feed and rest. Some of them are blotched or speckled, but few or none, I believe, have truly elaborate patterns. Nor do their costumes show more than a slight tendency toward oblitative shading, although the actual *translucence* of some kinds nearly compensates their lack of this device (—both weakening or even obliterating the light-and-shade of their own bodies, and preventing their casting shadows on the leaf- or flower-surfaces on which they sit). Some, in their early life, are cloaked—and, likely enough, protected, though certainly they are not *concealed*—by a covering, sometimes enormously developed, of white, soft, cottony down. These white-tufted bark lice are a familiar sight on willow and alder bushes.

Many other forms of hemipterous (and especially homopterous) insect might be mentioned, but mainly to show their general dinginess of coloring, which seems in keeping with their habits. Many of them are nocturnal and se-

clusive, like the cockroaches and earwigs, and have little or no special costume-development. Monochrome blackish, and unmarked, are also certain *aquatic* forms which live exposed to the daylight, such as some of the Water Boatmen (*Notonectidae*). It is likely that, for one reason or another, such insects are little sought as prey by the higher animals. But many of the larger sub-aquatic bugs are mud-colored, and some of them are decidedly pale-bellied.

Three important insect orders remain to be glanced at in this chapter, namely, the *Hymenoptera* (bees, wasps, borers, etc.), *Diptera* (flies, mosquitoes, etc.), and *Neuroptera* (dragon-flies, ephemera, etc.). In these orders obliterative shading does not play a uniformly dominant part. The insects comprising them are for the most part winged, and not only winged but actively aërial, and depend much on their powers of flight for escape from enemies. Some of them (dragon-flies, wasps, etc.) are themselves ferocious hunters, and too big and active to be eaten by the smaller insectivorous birds; while most of the flying *Hymenoptera* are terribly armed for offense and defense with poison-injecting stings, so that they are avoided by the general run of insectivores. Again, many of the *Diptera* and most of the *Hymenoptera* have no fixed perching postures relative to the prevailing light, but sit both above and under twigs and leaves, etc. This last fact alone is a sufficient reason why these insects, as a class, cannot greatly profit by obliterative shading. Some of them have it, to be sure; and it does work, more or less, when they cling to the undersides of things, or sit on a surface perpendicular to the earth,—provided, in both cases, that the surface belongs to an opaque substance, and is of sufficient extent to cut off much light from the insect's 'underside.' But since they also cling beneath slender twigs and translucent leaves, the obliterative effect of their counter shading, when they have it, must often be wholly upset, and this alone, as we have said, is reason enough why many of these insects should be nearly or quite as dark below as above.*

*In this book the term counter shading, when unqualified, means shading from dark above to light below. Insects like many *Diptera* that have their *darkest* details on their under side may profit by this in situations we do not understand. In general, it is not safe to deny to any coloration whatever, concealing functions under circumstances not yet recognized.—A. H. T.

In spite of their toughness and their terrible weapons, the stinging *Hymenoptera* are preyed on by a good many birds; and though as a rule not counter shaded, they are furnished with bold oblitative patterns of many sorts. The predominant type, perhaps, is a system of sharp transverse bars of dark and light, by which the insect is 'cut up' as the zebra is by his bands. Yellow and black are the prevailing colors of these patterns—though white and buff often take the place of yellow, and fuscous, tawny brown, and olive (plant-shadow colors) the place of black. Such markings are fundamentally and very potently oblitative against their wearers' average backgrounds of green vegetation in sunlight and shadow, and also amidst yellow flowers. Sometimes the pattern is simplified to a 'ruptive' one of two or three broad, unmarked patches of black and yellow, or black and orange—as on some of the bumblebees,—or still further simplified to a nearly monochrome costume of mingled plant- and shadow-like greenish yellow. Some wasps and bees, again, are uniformly almost black, and do not seem to have oblitative devices of any kind—except in the cases where the black is transfused with metallic color.* On the other hand, the transverse 'secant' pattern is often highly elaborated, consisting of many narrow, sharply defined, contrasting stripes, varied on the thorax and head by more broken and irregular markings. Such is the case with certain wood wasps or hornets, e. g., the common "Yellow Jacket" (*Vespa vulgaris*). Among the "sawflies" and "borers" (*Siricidae*, etc.), there is much variety in coloration as well as form. Glossy black, varied to steely blue, is perhaps the most characteristic color of these insects' bodies, but with it are often combined red, orange, yellow, brown, etc., in comparatively simple 'ruptive' and 'secant' oblitative patterns. Though lacking finer 'bark-pictures,' as well as counter shading, some of these borers, etc., are very inconspicuous when seated on the trunks of trees.

The wings of most *Hymenoptera*—as those of most of the other aerial insects mentioned in this chapter—are transparent, and hence essentially inconspicuous at all times, except when they brightly 'shine'—as a glass

* See footnote, p. 204.

window may. Sometimes they are merely translucent, being clouded with color,—such color, usually, as continues the background-picturing of the head and thorax when the wings are folded. In some cases, again, the wings are barred or spotted, and these markings have of course an obliterative tendency.

Iridescence is fairly common among *Hymenoptera*, and there are some—chiefly small kinds—which are equipped with uniforms of intensely vivid changeable color, ranging sometimes from bronze-red to blue-green or green-blue—like the back of the jacamar* among birds, but still more brilliant. Green is the dominant color of almost all such costumes, which are in the highest degree obliterative amidst vegetation, as we have already seen.

Some flies, too, have obliterative uniforms of iridescent green and blue, as everybody knows. They are, I believe, rarely or never as brilliant as the very finest of those worn by *Hymenoptera*, though often very rich and beautiful. The coloration of the *Diptera* in general differs but little, in essentials, from that of the *Hymenoptera*. [The bolder patterns and colors of the *Hymenoptera* fit their more energetic lives, which bring them against bolder background differences.]† But as the dipterous insects are softer and more defenseless, so are their concealing equipments somewhat more elaborately developed. Many are counter shaded, and habitually perch on the *tops* of things. Some of the more aerial, flower- and foliage-haunting kinds, have bright, transversely 'secant' patterns of yellow and dark brown or black; but this coloration is less characteristic of them than of the *Hymenoptera*. The close likeness in color and pattern between certain stinging wasps or bees and stingless flies has led naturalists to suppose that the flies are mimics of the bees. This resemblance, however, is quite in keeping with the similarity in the insects' forms, habits, and environments, and less remarkable than many other kindred cases which cannot possibly be connected with mimicry.

Flies are often dingily colored, and—especially those which have counter shading and more or less finely mottled patterns—fitted for "lying close" on

* See p. 90, Chapter XVI.

† Interpolation by A. H. T.

dingily colored surfaces. But many kinds are too promiscuous in their perching habits to profit by highly specialized coloration. Some have transverse, opaque, oblitative bands of dark brown on their fair, transparent wings, which would otherwise often be made conspicuous by their unbroken glistening. So also these flies' big, composite eyes are sometimes richly iridescent, and therefore, amid appropriate surroundings, well 'obliterated.'

The slender-bodied *Diptera*, such as gnats, mosquitoes, 'long-legged daddies,' etc., show few or no very remarkable developments of protective coloration. Being perchers on tree trunks, branches, and the dead-leaf covered ground, rather than on flowers and green leaves, they are usually dull colored—brown or grayish. Few have noteworthy body-markings, but many are obliteratedly shaded. Their transparent (and often daintily iridescent) wings are sometimes marked with oblitative spots or transverse bands of dusky—as in some of the well-known and well-hated *Anopheles* mosquitoes, and some of the 'long-legged daddies' or crane-flies (*Tipulidæ*)—while in others the wings are dusky brown with various opaque white markings. In fact, with a good many dipterous insects oblitative wing markings largely take the place of body markings, and the two broad wings when flatly folded amply mask the body, from a top view.

Wingless Hymenoptera, or *ants* in their apterous phases, largely lack notable oblitative or mimetic (?) devices, apparently relying for defense on their strong biting jaws and sharp acid excretions, as well as their extreme bodily toughness,—and passing much of their time in dark retreats of their own making. Their prevailing color is black or dusky brown, without oblitative shading. But some are tawny yellowish, some rust-brown, and some wear two or three of these earth-colors (including black), in clearly defined, unflecked 'ruptive' patches. Despite the sharply pungent acids they contain,—doubtless effective against some predators, ants are a favorite prey (sometimes even the sole (?) diet) of certain birds and beasts, and it is somewhat curious that they have not more highly developed disguises. Protective coloration would not avail them, however, against the most greedily and exclusively formicivorine

creatures, the ant-eating mammals, who dig open their strongholds and devour them by the thousand at a meal.

The *Neuroptera* (for convenience I follow the old arrangement and include the dragon-flies in this order) have, in the matters of outward form and disguising-coloration, much in common with the aërial insects already considered, but also a few salient points of difference. As everybody knows, the typical dragon-flies (*Libellulidæ*) sit with their four large gauzy wings fully outspread in a single plane. Too finely-netted to be perfectly transparent, these wings (in addition to being iridescent) are very often marked with bold obliterative bands or spots of opaque color, like that of sticks and bark and shadows—brown, brown-red, dusky—and these markings go far toward making the wings invisible against their average backgrounds.* The long and slender, stick-like body also is often marked with obliterative cross-bars, and obliteratively shaded. For the true dragon-flies, unlike most of the insects we have been considering, habitually perch back-uppermost,—or sometimes vertically, but rarely or never upside down. Hence in their disguise there is opportunity for counter shading and picture-patterns to come fully into play. The patterns they wear are of many kinds and many colors (green, red, yellow, blue, and black perhaps predominating), but almost all are transverse and most of them are very simple. Their counter shading of course takes in not only the attenuate abdomen but the thorax and big head; in short, the whole main form of the insect. The proportionately enormous compound eyes are usually rather dim-colored, but more or less iridescent, and very inconspicuous. Gorgeous iridescent foliage-color—cold blue to golden green and yellow—is common in the costumes of dragon-flies, and highly characteristic of some groups. As they are bird-like in their light, upright perching and sudden, swift, aërial sallies in pursuit of their flying prey (from which dashes they often return to the same perch), so are they bird-like—though also like butterflies and lizards—in the splendor of their obliterative, vegetation-picturing

* Their concealing-coloration probably serves them even more vitally in their aërial hunting than as a protection.—A. H. T.

costumes. The bodies (abdomens) of some kinds are so extremely slender and long that they are almost unrecognizable as belonging to an animate creature, looking more like grasses, sticks, leaf-stems, etc. Hence it would seem that they might also be subjects for complete *mimetic* disguise. And in fact, a few of the slenderest kinds have little or no oblitative shading, and present a close mimetic likeness to definite solid details of vegetation. Some of these 'mimics' are rich brown-red, like many of the sticks and twigs and weed-stems amid which they perch—others ochre-yellow like dead meadow-grasses,—etc. The wings, however, rarely or never contribute to the mimetic effect, but are almost always obliterated, with various blotches and bands of average background color. Among the *Agrionidæ*—less typical dragon-flies which sit with wings folded, vertically and longitudinally—there are probably cases of mimetic resemblance in which the wings play a part. On the other hand, these exquisitely gracile and sometimes gay-hued *Agrionidæ* are often equipped for obliteration—body, wings and all. Some which live always near water, usually perching close to its surface, have fair, bright-blue, obliterated bodies, which match their average watery backgrounds, under blue sky. Others have black, shadow-like wings, sometimes marked with a few oblitative white spots. On the whole, however, oblitative patterns, especially of the wings, are less in evidence among the *Agrionidæ* than among the *Libellulidæ* or true dragon-flies.

Oblitative wing-patterns (both dark marks on light, transparent wings and light marks on dusky ones) occur also among some of the groups of plainer-colored *Neuroptera*, such as the caddises, mantispans, scorpion-flies, ephemera, etc.; though many of these insects, especially the smaller species, lack such markings. Some, on the other hand, are colored throughout much like some of the red or golden brown, obliterated true dragon-flies. In general, the coloration of the smaller and dingier *Neuroptera* differs but little from that of the corresponding *dipterous* insects. Few have highly specialized disguises of either color or form, in the perfect state, though most of them are obliterated. Nor, with a few exceptions, are the larvæ or pupæ

of these insects, or of any of the insect orders mentioned in this chapter, of much interest in the present connection. Such of them as are aquatic but not mud-haunting are apt to have oblitative shading, more or less complete, but their coloration is seldom or never highly specialized. The larvæ of dragonflies are mud- and dingy-bottom-colored, counter shaded very scantily or not at all, and they are wont to lie concealed under mud or bottom-rubbish, leaving only their voracious heads exposed, ready for prey. Some hymenopterous larvæ (those of "sawflies," etc.) feed on leaves in the daylight, like lepidopterous caterpillars, which they resemble in many points of external appearance. But they have, as a rule, some active defensive (?) equipment (e. g., the power of jetting out pungent liquid), and their disguising coloration, in most cases, appears far less specialized than that of many caterpillars. (Some of these hymenopterous larvæ, indeed, in the rolled-up attitude characteristic of them when at rest, bear a remarkable likeness to snail-shells. But this is very likely a mere coincidence.) For the most part, the larvæ of the *Coleoptera*, *Hymenoptera*, and *Diptera* live hidden away from daylight and the attacks of the higher animals, except such as can dig or drill for them. Hence they are colorless, or monochrome, without patterns. In the case of insects whose metamorphosis is incomplete, like most of the *Orthoptera*, the earlier stages much resemble the later in their disguising coloration.

Spiders

Spiders (*Arachnidæ*) assuredly rival insects in the variety and high development of their disguising costumes. But we have studied them even less than we have studied insects, and hence must pass them over even more briefly.

There are wonderful developments of out-and-out mimicry among spiders. Many such cases have been described by naturalists, and many, doubtless, remain to be discovered.

But 'obliteration,' not mimicry, is our theme, and obliteration is the rule, not the exception, in the disguisement of spiders. The many kinds which in

their perching have the requisite constancy of position relative to the prevailing light, are, in almost every case, obliteratively shaded. Thus their great, globular bodies are 'flattened out,' and, with the further aid of background-picturing patterns, of one sort or another, practically effaced. Some wear tree-bark and rock-surface pictures, more or less generalized, others leafy or grassy ground pictures. Those which swing free in flat, open webs have sometimes very bold and brilliant patterns—flower-like, dewdrop-like, and like black shadow-vistas amid small, sunlit vegetable forms. Some of these brightly patterned spiders have the upside-down habit, and their counter shading is of course inverted, like that of so many caterpillars. Some of them, with globose and highly colored abdomens, have slender, flat gray heads, duly counter shaded, which in time of watch and quiet are laid against a specially constructed patch or trail of glaucous, opaque web, which they match exactly. (See Fig. 127.) The big, round abdomen, meanwhile, is either separately but equally well 'flattened' by counter shading, and 'merged' by picture-patterns into its background of sunlight and shadow, grasses and flowers, or it presents a mimetic likeness to some single, solid landscape-detail—flower, berry, seed pod, or curled-up leaf.

'Hole-picturing' (Chapter XXII, Fig. 120) is a common detail of disguise among the more richly patterned kinds.

The dainty white spider* shown in Plate XVI, Figs. V, W, X and Y, well illustrates a fact to which we alluded early in the book, namely, the *greenness* of foliage-filtered sunlight, potent in its visual effect on animals' colors, particularly white. In some views amidst sunlit leaves, this actually porcelain-white spider (Figs. V and Y) looked even greener than Figs. W and X show him.

The next and final chapter will treat scantily of the most beautiful and elaborately colored of all insects, if not of all animals, namely, the *Lepidoptera* in the perfect state, or butterflies and moths.

* This species has also a *yellow* phase.

CHAPTER XXVII

BUTTERFLIES AND MOTHS

I. Butterflies

THESE gloriously resurrected "worms," these favorites of man from ancient times,—creatures which he has been wont to consider purely and simply bright and beautiful,—are in reality all tricked out in fine and powerful disguising-costumes, which make them, each in its own special situation and headquarters, invisible or scantily visible to their enemies. Famed though butterflies are for their gay and wondrous gaudiness, there is probably no single kind among them all whose coloration is not *concealing*, in its true and particular environment, under the typical and appropriate conditions. In civilized lands, species may and doubtless often do survive their fittest environments, when these are destroyed by man. Hence it is only in the primeval wilds—e. g., the great tropical forests—that the butterflies and their proper surroundings can infallibly be found together, and their interrelationships rightly studied. Nor is it easy to imagine any pursuit in natural history more profoundly fascinating than the study of the special disguising-costumes of tropical butterflies. Even as the subject was known to naturalists who recognized only *mimicry* and an exceedingly limited range of more nearly *obliterative* "cryptic" color schemes, it was already a large and very interesting theme. But it has now grown beyond measure greater and more interesting, since by the disclosure of the simple laws of true oblitative coloration, it has been extended to include practically all butterflies and moths.

If a man well fitted for the task were to devote his whole life to the study

of the disguising coloration of the butterflies (and moths) inhabiting say a few square miles of Brazilian forest, he would doubtless be discovering new wonders even of essential principle on the last day of his hunting.

Our own knowledge of the subject is of the slenderest and most fragmentary sort; nevertheless we can open several vistas into quite untrodden fields of exquisite truth. Some few of our readers are already familiar with my father's paper on "Protective Coloration in its Relation to Mimicry, Common Warning Colors, and Sexual Selection,"* wherein most of his discoveries concerning butterfly coloration are clearly outlined. The present chapter contains but little which was not at least foreshadowed in the above-named paper, or in an article by me published in the *Century Magazine* for June, 1908, and the reader must take it as a recapitulation and enlargement of these earlier essays.

In the first place, the obliteration of butterflies is a very different problem from that of vertebrates, or even large-bodied insects. Obliterative *shading* is but scantily called into play, for their principal members, their wings, are flat and paper-thin. Their slim, cylindrical bodies are almost always counter-shaded, to perfection, but this is, comparatively, a small detail of their disguise. Their great flat wings, with their characteristic outlines, have to be disguised by other means. In the case of birds and beasts, etc., Nature has to use artifice and deception to make them into 'canvases' for background pictures; but butterflies' wings are actually flat planes, all ready for the pictures. These Nature gives them, to the highest imaginable degree, ranging through a scale of variations marvelous in its immensity, yet furnishing each species with a costume well fitted to its own peculiar mode of life (although, as already explained, the perfection of the fitness may be no longer discernible, since it is often marred by rapid, man-wrought changes in a butterfly's natural environment).

This great agglomeration of differing butterfly types (as far as it is known

* Published in the "Transactions of the Entomological Society of London" for December 24, 1903.

to us) may be separated, for our purposes, into several main groups,—such as that of *sedentary* and that of *aërial* species. The division is somewhat arbitrary, since practically all butterflies are strong of wing, and there is such a multitude of intermediates connecting the two types that it is impossible to draw a sharp line between them; nevertheless, the terms cover, in the aggregate, an essential difference of characteristics. Among the *sedentary* species, then, occur all the most highly wrought, minutely detailed “cryptic” patterns (a good many of which have been recognized as such by naturalists in general). They are worn by butterflies which pass most or at least very much of their time at rest, sitting motionless, with wings—in most cases—folded perpendicularly over their backs. Some of them are developed *mimetically*, even to an extraordinary degree—e. g., the famous leaf-mimicking *Kallima inachis*, of India. There are many other pronounced though less extreme cases of whole-leaf mimicry among butterflies, not only in the genus *Kallima*, but in nearly allied as well as in some remote genera—and even among restless ‘aërial’ species. One such, which I believe has never been recorded, is that of the abundant and familiar South American *Heliconius melpomene*. On wing amidst the uniformly bright-green lower foliage of the tropical woods, it is as often *conspicuous* as any patterned butterfly could well be. [The gaudy costume of this red-and-black *Heliconius* is evidently one more example of coloration adapted to the wearer’s moments of greatest danger. Haunting, while on wing, the thickest foliage, where birds cannot easily catch it, it is probably most in danger when intently feeding among flowers. (At such times butterflies sometimes allow themselves actually to be plucked off their perch by one’s thumb and finger.) Probably this *Heliconius* finds such an intoxicating feast in the tops of certain great flowering trees that it there becomes an easy prey to any birds that want it.]* But in its nightly roosting (begun in the early twilight), it is a *leaf-mimic*, of no mean achievement. It roosts—as we have seen it—gregarily, several individuals (three to ten or more) occupying the same leafless twig, beneath which, at pretty regular

* Interpolation by A. H. Thayer.

intervals, they suspend themselves, with closely folded wings. The undersides of these wings, now alone exposed, resemble the upper sides in pattern, but are very much dimmer, the black being replaced by ochrous dusky brown and the red by soft, hoary pink. In addition, the lower wings are narrowly bordered on the anterior edge with pale yellow, and the slender body bears spots of the same color, while the bases of the fore-wings and the immediately adjacent portions of the body are marked with small red spots. Half of the broad pink (= red) wing-band shows beyond the tips of the folded lower wings. The whole form of the insect thus folded and placed, though without any very peculiar modifications of contour, is almost exactly like that of many slender, entire leaves common in the forests it inhabits. But observe, it is not like a living leaf in color, nor does it (in our experience) immerse itself in a sea of foliage, there to be the single counterfeit among many genuine originals. Instead, as I have said, it selects, with several companions, a leafless twig, in a spot where leaves are few, and together they suspend themselves beneath this twig in the semblance of a row of drooping *dead* leaves which still show traces of live color (the fine yellow lines and spots), and are each marked with a partly faded pink disease-spot (the pink band crossing the fore-wings) and some brighter red disease-flecks near the leaf's (= the butterfly's) base. That this resemblance is not *fancied*, but real and very potent, will, I think, be attested by anyone who studies the roosting-habits of *Heliconius melpomene*. There are doubtless many fine cases of this sort of mimicry still to be discovered. But, as we have repeatedly affirmed, mimicry is not our theme in the present book, wherein we must confine ourselves almost wholly to the far larger and more intricate problem of *obliterative coloration*. Nor is it to be supposed that mimicry rather than obliteration is the rule in any large group of butterflies. On the contrary, the cases of out-and-out butterfly mimicry are relatively very few indeed, and scattered, while 'obliteration' is universally and most variously achieved among them.

Many of the butterflies which rest amid live foliage and flowers have daintily detailed and at the same time 'generalized' pictures of their varie-

gated and varying backgrounds of more or less distant leaves, twigs, blossoms, etc., with their lights and shadows, and with vistas through the nearer background to the further. Such patterns occur on both the upper and the under sides of the butterflies, but are usually minutest on the undersides. They are characteristic of species which sit with motionless folded wings—or in other words, those of the 'sedentary' type. Some of the South American species of the genus *Metamorpha*, as *M. dido*, are good examples. So, of a somewhat different type, is the European "Orange-tip" butterfly (*Euchla cardamines*) whose floweret-picturing is well known. (See Fig. 128.) This is in part almost mimicry, though compound, for the nearer flowers look as near as the actual wing-surface on which they are rendered.

More restless kinds, which alight only momentarily, keeping their wings outspread, or continually opening and folding them, have more generalized leafy or flowery background-patterns, often strongest on the *upper* side. These we will discuss more in detail later, when we have finished our fragmentary review of the group of 'sedentaries' or closed-winged perchers, the butterflies whose most highly specialized obliterative coloration is on their *under*-sides. This group may be subdivided as follows: 1. True leaf mimics (already mentioned, e. g., *Kallima inachis* and *Heliconius melpomene*.) 2. Those butterflies whose *obliterative* pattern pictures a varied background of live leaves, flowerets, and other richly colored details of living (and dead) vegetation (already mentioned, e. g., *Metamorpha dido*, and, in part, *Euchla cardamines*). 3. Obliteratively colored bark- (and rock-) butterflies. These are many, although bark-picturing patterns in their supreme development are more characteristic of moths than of butterflies. All (?) the multitudinous moths which are addicted to perching on tree trunks sit with wings flatly applied to the bark, whereas the butterflies of like proclivities, with a few remarkable exceptions, of which I shall soon say more, keep their wings, for the most part, perpendicularly folded, so that their background—that of their full side view—is necessarily much more variable. Nevertheless, many of these butterflies bear colors and minute patterns on their undersides which



FIG. 128. Four Orange-Tip Butterflies (*Euchloe cardamines*) on cow-parsley, showing the flower-picturing on their undersides, and the "cutting down" of their out spread topview to a flower-like form by darkish tips.

Photographed from nature by Percy Collins.



FIG. 129. Butterflies on vegetation (*Papilio ajax*, *P. asterias*, *Basilarchia artemis*, and *Argynnis idalia*), their dark patterns merging with the shadowed portions of their backgrounds, leaving their light markings standing out like lighted leaf-and-flower forms, at various distances.

Photographed from nature. (Dead butterflies).



FIG. 130. Light-colored (*pterine*) butterfly with background shadow-pictures on the borders of the forewings.

Photographed from nature (dead butterfly).



FIG. 131. Small Tortoise Shell Butterfly (*Vanessa urticae*) outspread on stony ground. His light border-patterns carry the aspect of the background into his wings, disguising their real contours, and making him look like a hole overlapped by lighted ground-details.

Photographed from life by Cherry and Richard Kearton. Courtesy Cassell and Co.

are decidedly of the tree-bark (or rock-surface) type. These patterns are at once finer and less fine than those of the *flatly-applied* lepidoptera. Less fine, as they less minutely and exactly depict one especial type of surface in one especial view; more fine, in that they combine the elements of several varieties of background at somewhat varying distances,—the bark of the tree on which they sit, with its markings lessened by distance and foreshortened in extreme side view, front or side views of bark-surfaces on other, farther trunks or branches; or even still more extended vistas of the mixed forest background. Examples of this type, in full and simple development, are the several familiar northern butterflies of the genera *Grapta* and *Vanessa*, as well as many nearly or remotely allied tropical forms. Tree trunks, tree branches, and rocks are the characteristic resting-perches of these butterflies, though they are by no means confined to them—any more than their patterns, beautiful and efficient for ‘obliteration’ though they are, show that ultimate touch of specialization which would best qualify their wearers for strictly specialized perching-habits. They are swift, sharp fliers, these *Graptas* and others, and their upper sides have as a rule wholly different colors and patterns from their lower, with different obliterative functions. But that is another story, to be told later in the chapter.

Some of the much larger tree-trunk butterflies which habitually sit with folded wings, such as the famous *Calligo eurylochus*, and others of that genus, miscalled “Owl Butterflies,” have a subtle obliterative pattern in which the picturing of near tree-bark is almost wholly replaced by that of more extended and diversified vistas of the brown forest interior—a pattern, in short, more like that worn by certain forest birds, such as the Ruffed Grouse. (See Plate II, and Chapter VI, pp. 38-41.) This accords with the fact that, owing to their great size, these butterflies can almost never have as a complete background for their ‘profile’ the bark of the tree on which they are perching, as the small *Graptas*, etc., often can. (This is all the more likely on trees with rough and flaky bark—a condition more characteristic of northern trees than of those of the *Calligo*’s native forests.) The species of *Calligo* which

we have studied at large, perched, as we saw it, rather near the ground, often within a few inches of it—and there are evident traces of ground-‘picturing’ in its beautiful mottled pattern. Thus it is something of a connecting link between the tree-bark butterflies and our fourth group of ‘closed-winged sedentaries,’ the *ground-picturers*. The variety in the at once epitomized and generalized ground-picturing patterns worn by these low-perching butterflies is almost boundless, and it would be folly for us here to attempt anything beyond a brief general description of a few main types. Some of the species belonging to this group are haunters of open fields and meadows, and there is accordingly a frequent outcropping of grass- or even field-flower-picturing in their costumes. But by far the greater number, at least among tropical butterflies, are sylvan, and the most prevalent feature of their widely varying patterns is the picturing of prostrate dead leaves and sticks. In one form or another, in more or less clear development, almost all the sylvan ground-perching butterflies wear these pictures. Such things as several dead leaves together, overlapping, each with a dark shadow underneath its border, blent softly on one side and on the other ending in sharp contrast against the bright edge of the leaf which casts it; leaves partly curled up, with holes and ragged borders, crowded and distorted in perspective; dull sticks with clear-cut shadows, bright, strawlike sticks standing out over broad, blurred shadows; or objects like these combined into fine, sharply mottled patterns by perspective,—such are a few of the commoner details of the unlimitedly various backgrounds of forest floor against which these butterflies are seen, when they are seen at all; and such, by the same token, and in very truth, are the details of their equally various and marvelously potent oblitative picture-patterns. Being such little creatures, and sitting so low down, they are secure of comparatively near backgrounds—relatively, for instance, to the species which perch high up on small twigs and leaves, or even those that sit with perpendicularly folded wings on tree trunks. On the other hand, their case is different from that of the flatly applied lepidoptera, whether moths or butterflies, and whether of tree trunks or the ground, in that their backgrounds

are almost always at least a few inches distant from them, and subject both to much variety and complexity of detail and to a good deal of refinement and distortion by perspective. Some of them, indeed, wear rich, varied ground-scenery pictures, scarcely rivaled by those of the most finely patterned forest birds. Others are colored very simply, with either many very faint and delicate or few and bold oblitative markings.

Passing now to the class of *aërial* butterflies, i. e., those which spend a much greater proportion of their time in flight, and do not characteristically "sit close" on perches, we find, of course, new general schemes of coloration. But as I said before, the two classes are by no means clearly separate, and hence their distinctive color schemes are subject to interminglement, of many forms. In the first place, most of the 'sedentary' wing-folding butterflies, such as we have been considering, are 'aërially colored,' so to speak, on the *upper* side. That is, their upper sides bear either such colors and patterns as decrease to the utmost possible degree their inevitable conspicuousness in flight, such as tend to obliterate the wings of the perching insect when they chance to be expanded, or such as 'dazzle' in the way mentioned in Chapter XXVI, p. 199, and of which the reader is soon to hear more. ('Dazzling'-colors of this kind, indeed, are confined, in their full development, to close-folding 'sedentary' butterflies, and, contrariwise, there are few such butterflies whose upper-side colors do not on occasions perform this 'dazzling'-function, however largely oblitative may be their general use.)

There are butterflies which alight very often, but do not stay long in one place, and either keep their wings outspread, or are continually closing and opening them. These, intermediate between the sedentary and the aërial types, share the color schemes of both,—perhaps inclining, in costumes as in actions, to the aërial. Their trick of wing-waving, however, is common, in more or less pronounced form, to most butterflies,—some of the tight-folding 'sedentaries' alone being nearly exempt from it. (In conjunction with the less minutely detailed patterns of many of the species that practice this trick, it would seem to be a general measure for 'assimilation' with their surround-

ings—a movement imitative of the swaying and trembling of the nearly always breeze-blown leaves and flowers and twigs amid which they sit.) Even when perching, these butterflies of the 'intermediate' class expose the upper side as freely and fully as the lower, if not more so, and in many cases the upper side is the more specially and minutely patterned of the two. The prevailing color of all such butterflies, or at least the color which occurs almost unvaried on the greatest number of species, is dusky olive brown,—'black' which is not black. This is just the average tint of the smaller shadows amidst vegetation. On this groundwork of perfect shadow-color are painted all sorts of leaf, sun-fleck, and flower-pictures—more delicate and elaborate on species which more frequently alight, bolder and simpler on the more constantly aerial kinds. (See Fig. 129.) The commonest tint of the light 'picture'-markings, which stand framed in the pure, elusive shadow-color, is bright—(often somewhat greenish) yellow,—and this, after white, is the color of the majority of flowers. Furthermore, it is the color—barely clarified—of almost all brightly sunlit foliage. No wonder, then, that the presence of this color in clear and delicate generalized picture-patterns, with the due amount of contrasting, dusky shadow-tint, strongly tends to 'obliterate' the broad, flat wings of butterflies. So many and so various are these picture-patterns, in kind and in degree (of elaboration and finish), that it would be hopeless for us here to attempt a comprehensive account even of the main types of them. Here as elsewhere in our book, the description of a few characteristic cases must suffice.

Papilio polydamas, of North America, and some of the dark *Satyrinae*, will serve to typify the butterflies which have a shadow-like ground-color overlaced with bright, generalized pictures of living vegetation. Some of these, *Papilionidae* especially, have such patterns beautifully clear on the under as well as the upper sides, and often rest with tightly folded wings. The patterns of their under sides, in fact, though usually less bold and bright than those of the upper, are also as a rule more fine and delicate, as if to admit of a closer inspection. And in truth it is chiefly at times when the butterfly has relaxed

its vigilance and is sitting more or less inert, that the pattern of its underside is displayed in full. Also, the side view is apt to have a somewhat more distant background than the full top view,* and hence requires a more delicate pattern for 'obliteration.'

Sun-flecks are another important feature in these picture-patterns of the *Nymphalidæ*, etc. They are big circular marks of yellow or whitish, sometimes rimmed with violet or blue, and set in leaf-shadow color. The blue border is a mere intensified rendering of the sky-tinged rim around real sun-flecks, which are in fact camera-obscura images of the sun surrounded by blue sky. Such markings are worn for instance by *Nymphalis bolina* and by the male of *Hypolympas misippus*. Usually, as in the case of *H. misippus*, the encompassing dark tone (with or without a skyey rim) ends in sharp contrast against the spot; sometimes, however, it is blended into it, as is the case with real sun-flecks also. Then there are sun-streak pictures—markings that depict sharp ribbons of sunlight alternating with bands of dusky shadow. Patterns of this kind are a most characteristic element of some woodland scenes, particularly in tropical woods, amid fringed palm leaves, and other, smaller, finely pinnate foliage,—and bright pictures of them are worn by some of the butterflies inhabiting these forests. *Heliconius charitonia*, of the West Indies, etc., is a fine example. Indeed, the disguising-coloration of this or a closely allied butterfly has been, ere now, in part, well and accurately analyzed and described—by Mr. C. W. Beebe, of the New York Zoölogical Park. But such a costume as *Heliconius charitonia* wears is not limited to the single function of still-sun-stripe-and-shadow picturing described by Mr. Beebe, admirably though it serves that function. It is also highly 'obliterative' as the *Heliconius* flies about rather slowly amid feathery, sunlit foliage. The irregular and not rapid motion of the butterfly's vividly striped wings fits into and merges with the mazy scintillations of the fine-cut,

* Because the butterfly is likely to be in closer contiguity with the nearer details of its background when flatly outspread, than when folded and projecting outward perpendicularly from its perch.

waving leaves, sunlit and bright above dark shadowy interstices. Again, when the *Heliconius* is quietly perching, its yellow marks may produce the effect, additional to that described by Beebe, of vistas through shadows or dark twigs to a more distant sunny background. In fact, this effect is interchangeable with the other (that of light details or marks laid on or standing above a shadowy background) in almost all the numberless obliterative patterns of this general character, both on butterflies and on other animals. According to the creature's position and the character of its background, at any given moment, its pattern will incline toward one or the other of these two equally deceptive and obliterative effects.

The beautiful South American *Metamorpha dido*, already mentioned among 'close-folding sedentaries' wears on its upper side a bolder green and black-laced pattern, which makes it extremely 'dim' and elusive in its flight amidst foliage. But this pattern must also on occasions serve the butterfly at rest, for though cruder than that of the underside, it is too delicate in detail to be merely a flight-pattern. For flight of course tends to cancel the visibility of markings, blurring and blending forms and colors, and even on the most slow-moving butterflies only big, bold patterns can maintain a clear effect in flight. Many of the more aërial butterflies have such big, bold patterns, however. In addition to the types described and figured above, those represented by some of the other *Heliconidæ*, and some of the South American green and black and red *Papilionidæ*, are notable. A butterfly thus patterned with black and yellow (e. g., *Heliconius sara*), or with black and green and red (e. g., *Papilio gargasus*), will never at any point in its airy course relieve clearly, in full contour. As it passes across shadowy interstices amidst vegetation, its black will disappear, leaving in sight only a skeleton pattern of yellow, or green and red; and while it is passing brightly lighted leaves and flowers only the black will show. Thus the watching eye is condemned to see only flickering glints of color, instead of seeing the whole form of the moving insect, as it would were the insect monochrome. Such constantly repeated metamorphoses of aspect, amid the vegetation's varying

movements, must strongly tend to baffle a pursuer. *Heliconius melpomene* has, as I have already mentioned, a still simpler 'ruptive' flight-pattern (on its upper side), and one which seems but poorly fitted to disguise it among green leaves alone. Some of the beautiful Hummingbird Papilios of South America have much the same coloration, with the addition of a pair of sea-green or pale-blue spots. Such are *Papilio gargasus* and several kindred species. This coloration is admirably fitted to disguise its wearers when they hover, hummingbird-like, over, or momentarily perch on, gay-colored and brightly lighted flowers which relieve against shadowy underspaces. But *Heliconius melpomene*, as we have seen it, is less of a blossom-haunter, and with its still simpler pattern, of black and red alone, it is not always as inconspicuous, even in its transitory flower-attendance, as patterns could make it,—as patterns in fact do make many of its relatives.* Like the Scarlet Tanager, however, and other somewhat anomalously costumed woodland birds, *melpomene* is a haunter of dense, protecting foliage. Through the mazes of woodland greenery it threads its rather leisurely way with wonderful adroitness, flying with short wing-beats and much sailing, and its skill in dodging in and out and round about amid leaves doubtless makes it a difficult quarry for flycatchers. There are many other remarkable South American tropical butterflies of the same long-winged type. Especially noteworthy are those of one of the so-called "Batesian and Müllerian mimicry groups"—such species for instance as *Lycorea atergatis*, *Tithorea megara*, *Mechanitis veritabilis*, etc. Their general scheme of coloration shows much affinity with that of *Heliconius charitonia*, and much also with that of certain types of the terrestrial tight-folding class. So also in their habits they are nearly midway between the two extremes. They perch low down in the forest, often very near or even *on* the ground, and their costumes contain a good deal of rich ground-brown—the universal brown of the tropical underworld, described in Chapter XIX. But though not, like *Heliconius charitonia*, *sara*, *melpomene*, etc., truly 'aërial,' they are restless, and spend much time on wing, often rising into the borders of that region of abundant foliage and fre-

* See the interpolation on p. 214.

quent sunbeams which is the headquarters of *sara*, and other yellow and black or green and black 'aërial' butterflies. In their perching, too, they show infixitude of habits, often sitting with wings closely folded and sometimes with wings more or less expanded. Their upper and lower sides are much alike, but the lower has usually a somewhat finer pattern, which is highly 'obliterative,' although less definitely and minutely 'ground-picturing' than most of the patterns worn by true terrestrial 'sedentaries.' In fact, the costumes of these more sluggish "*heliconoid*" butterflies contain just such a compromise between bolder oblitative flight-patterns, in foliage and sun and shadow tints, and finer, brown-ground-picturing perch-patterns, as a knowledge of their habits would lead us to expect. The supposed mimetic interresemblance of these butterflies' costumes was alluded to, though not specifically, in our Introduction. Another group of South American butterflies believed to show the same sort of mimicry is made up of species with more or less transparent wings. These also are aërial, their wings are long, and marked, in various patterns, with opaque bands and spots of dusky, or sometimes brighter color, inclosing spaces of pure glassy transparency. Of course these insects are normally almost invisible, not only when they sit still (with a background of green leaves or brown ground, or what-not) but even in their leisurely flight through the forest aisles. "One of these clear-wings," says Bates, the great English naturalist, in his wonderful book "A Naturalist on the Amazons," "is especially beautiful, namely the *Hetera esmeralda*; it has one spot only of opaque coloring on its wings, which is of a violet and rose hue; this is the only part visible when the insect is flying low over dead leaves, in the gloomy shades where alone it is found, and it then looks like a wandering petal of a flower."

Iridescence plays a great part in the 'obliteration' of butterflies, especially aërial ones. Indeed, splendid iridescent colors are enrolled in the service of the more restless butterflies with an amplitude and variety scarcely to be matched in the world of birds. We have already (Chapter XVI) given a general analysis of the oblitative power of highly changeable color. The

reader will readily perceive how well adapted butterflies are to profit by this factor of disguise. Though prevalent in almost all the main butterfly groups already named, and often playing a part in minute picture-patterns, lustrous changeable color reaches its highest development among aërial species, and especially those of the skyey over-realm of tropical woods (Chapter XIX, pp. 107-108). Its range of tint is chiefly from reddish purple to golden green—a scale which includes all the hues of open sky and sunlit foliage, and glowing interstitial shadow. Sometimes, for instance, as in the case of some of the big South American *Morphos*, almost the entire upper surface is covered with immaculate iridescent color. These glittering blue butterflies are for the most part highly aërial, and their color works like that of the peacock's neck (see Plate I), matching, in flashes, sky and sky-lit foliage, etc. Some of them, on the other hand, are also much given to perching low down in the forest, and here their vivid blue, in coöperation with their brown, picture-patterned undersides, achieves 'dazzling coloration,' of the active, metamorphic sort. The bright color of such species is apt to be less iridescent and shiny than fixedly lustrous, shifting somewhat in minor tints and in intensity, but in main effect staying always blue, whereas the blue of the more aërial and tree-top-haunting *Morpho anaxibia*, for instance, shifts to purple and to green in vivid play and interplay of keen metallic tints. The 'dazzling' effect produced by some of these *Morphos*' costumes is often most pronounced. Imagine watching such a butterfly as it sails along through the brown aisles of a South American jungle. Its broad, immaculate blue wings look almost luminous in their glaring brightness, and the eye follows them easily and fascinatedly along their course. Suddenly the butterfly alights, folding its wings sharply together, and—is no more. The eye must be well trained indeed to recover from its 'dazzlement' in time to mark the insect down exactly. It is like trying to see clearly after staring at the sun. More than this, the abruptness of the metamorphosis, the instantaneous eclipse of the bright thing which the eye has been following, has in itself a very confusing effect. The butterfly sits motionless, and will not stir its folded, dark-brown wings, covered with

forest-pictures, until its disturber comes within a few feet or even inches of it, when it expands them suddenly and goes flashing off through the forest, only to repeat the trick. This kind of 'dazzling' is doubtless a frequent factor, of greater or less relative importance, in the disguising coloration of butterflies, and also of moths, which we shall presently consider in some detail.

Lesser iridescence—the soft, masking sheen of bright, or especially of dusky, markings, is common to a vast majority of butterflies—as, indeed, of highly patterned animals of all classes. Its obliterative effect is constant and essential. Such lustre of dusky markings in a butterfly's picture-pattern is frequently offset by a complete sheenlessness of the accompanying light-colored stripes or spots, and this combination is potent to 'obliterate.' For the dark parts, with their ever-varying play of soft rainbow-sequences of tint, together form, as it were, a sort of fluid medium, a positionless, mutable atmosphere, in which are suspended the definite and sharp details of the picture-patterns, with their fixed positions. Or, to express it still more figuratively, the butterfly has first been converted into space, and then that space furnished with such material details as it should normally contain. Not merely among butterflies, but throughout the animal kingdom, such minor lustrousness is a common and important factor of obliterative pattern. A perception of its use is indispensable to a full understanding of obliterative coloration.

So far we have considered butterflies' patterns chiefly with regard to their ultimate effects of 'background-picturing.' We must now examine more particularly the principles which underlie these effects, the principles of the intrinsic 'obliterativeness' of patterns. These have been touched on in our earlier chapters, but since many of them show up in much clearer application in the costumes of butterflies than in those of any other animals, they shall here be described anew. The term 'dazzling coloration,' in its widest sense, might include them almost all, for they almost all deal with devices and systems of devices for the reduction of one form's or detail's conspicuousness by the blazoning of some other detail. The butterfly's organic form

possesses characteristic actual contours and internal details; these, if the butterfly is to elude the eyes of its enemies, must be made as inconspicuous as possible. How should this be done—how has Nature done it? By the introduction of *sham* details, of such plainness, and so bestowed on the butterfly's surface, as to eclipse and neutralize the real but faintlier showing details and contours. *The stronger the pattern appears, the dimmer appear the forms and outlines of its wearer*—as the reader has been shown. Patterns, then, in the oblitative costumes of butterflies, are so placed as fundamentally to thwart the conspicuousness of their wearers' forms; and, at the same time, the resultant effect of these intrinsically 'dazzling' and 'oblitative' markings, under the normal conditions, is of perfect *picture-pattern*. These two principles, in fact—if indeed they can be called *two*—work in practically inseparable combination and coöperation. Thus is achieved for butterflies the highest possible degree of average inconspicuousness—as, indeed, it is achieved for the many other types of animal we have considered. Only, the case of butterflies is simpler, because the third great principle, *oblitative shading*, being confined to their bodies, plays, as to *area*, a comparatively small part in their disguise.

Let us look at a few concrete examples of these more subtle phases of 'dazzling'-coloration. There can be no doubt that the entire arrangement of markings on the most brilliantly and elaborately patterned of butterflies is hostile to the conspicuousness of the insect's general form: let us then consider some of the details of this 'eclipsing'-system. Among the markings whose function is the masking and 'breaking' of external contours, two are especially notable. One is the diagonal cross-band at or very near the end of each fore-wing, which 'cuts off' a bigger or smaller tip, thus marring the characteristic outline; the other is a band, or more commonly a series of spots, following more or less closely the real contour, in just the right position to neutralize the real contour's conspicuousness by distracting the eye's attention to the *anti-contour's* vivid details, which serve as background-pictures, and are as a rule supported in this effect by other and more varied internal

patterns. Dark is conspicuous against light, and *vice versa*—accordingly, light-colored butterflies are apt to have dark tips and borders, with such internal contours as work to bely the insect's form when these markings 'merge' with dusky backgrounds, while dark-colored butterflies are apt to have corresponding light-colored markings. (See Figs. 130-131.) As we have seen in earlier chapters, a living animal in nature is subject to momentary vicissitudes of dark and light 'relieving.' When one side of a bird shows dark against its background, the other side, seen from the opposite direction, is very apt to be 'relieving' light. Hence, in very many cases, the best a creature can have in the way of generalized disguise is the clearest development of 'ruptive' pattern, made of sharply contrasting light and dark marks. It is this 'ruptive' effect that seems chiefly aimed at in the costumes of many butterflies, though the resultant appearance is nearly always of adequate 'picture'-pattern. Their background is to be a changing patchwork of dark and light, and they themselves are to be both shadowed and lighted, in rapid, ceaseless alternation; hence they must wear both dark and light in sharply contrasted, form-belying patterns. 'Tip-clipping' bands of dusky are very characteristic of light-colored butterflies, including some which bear a mimetic likeness to single flowers. Of such mimics there are doubtless many. But this flower-like-ness is seldom or never minutely perfect in the sense of the leaf-like-ness of *Kallima*, though sometimes very effective. Cases of this sort may be found among field butterflies, notably the *Pierinae*. These are usually yellow or white—the commonest colors of flowers—with scanty markings. Their fore-wings, however, in the cases in point, are 'clipped down' to a shape more normal to flower petals by diagonal dark tips. That is, these tips, being of the regulation 'interstitial shadow color,' strongly tend to look detached from the light-colored wings, and merged with the shade beyond. Often these dark rims or tips—as also others of the larger shadow-picturing patches of dark color on butterflies—contain small markings; dim ones, like faint pictures of more or less distant plant-details in shadow; bright ones, like lighted near details above the shadow; pure white dots which

look much like little gleaming dewdrops. Another characteristic marking of these light-colored, flowerlike butterflies is a quartette of small dark flecks—one fleck near the middle of each wing—which form, with the two club-tips of the antennæ, when the insect is symmetrically outspread, an almost perfect circle. These six little marks look much like *stamens*, and greatly enhance the flower-aspect, which often is yet further helped by a dusky clouding of the inner portions of the wings, blending outward into light and inward darkening toward the dark body; all of which produces a flowerlike appearance of concavity.

But to return to the subtler 'dazzling' coloration of the background-picturing butterflies. One more important special marking of this kind must be considered, namely, the so well-known 'ocellus' or eye spot, a marking which occurs in many forms and on many animals, but probably reaches its highest development among birds and butterflies. At its full, as it appears on the Argus and Peacock Pheasants, and on several butterflies, an 'ocellus' is a clear and strong representation of a sharply shaded sphere, or even of a ball and socket, forms which may fairly be said to represent the quintessence of substantiality. Among ocellus-bearing butterflies, the genus *Calligo* is particularly notable. Some of the members of this genus, such as *C. eurylochus*, are popularly known under the misnomer of "Owl Butterflies," from the remarkable but undoubtedly fortuitous (?) resemblance of their underside, when the wings are outspread, to the face of an owl, with wide-open eyes. The *Calligos* have already been mentioned among close-folding butterflies whose undersides bear an exquisite picturing of more or less extended brown forest views. In the midst of these finely marbled forest-pictures stand the big, black-and-yellow eye spots, one on each hind wing. Except in flight—when, indeed, the markings of the underside are so shadowed and jerked about that they have little effect of any kind—only one ocellus can be seen at a time, for the perching butterfly always (?) keeps its wings perpendicularly folded. Each obliterated-patterned side bears its one bold ocellus, which acts as a loadstone or 'dazzler' to the sight, diverting it from the faintly-

traced outlines of the wings, and helping all the faintly-patterned part of their broad surface to 'melt away' into the background. (See Fig. 132.) The sharply visible ocellus, therefore, either seems to be standing alone in air, or, more characteristically, 'recedes' with the rest of the wings' surface, and passes for a detail of the background. In either case, although in itself highly visible, it looks like nothing edible to insectivores, while by its very brilliance it masks and hides the organic forms of its wearer. Such is probably the main use of major ocelli in the disguising costumes of butterflies. *Minor* ocelli are often purely and simply details of background-picturing. Some, for instance, seem closely imitative of gleaming dewdrops, and of dewdrops surrounded by shadow, while others look like holes in leaves—dead or living, as the case may be. Some, especially of moths, are actually transparent. Between minor and major ocelli there is a smooth gradation, a complete chain of intermediates, and here as in all such cases it is impossible to know just where one function ceases and the next begins. Indeed, the two functions are more or less coördinate and interwoven throughout this whole gradation, for the biggest, most specialized 'dazzling' ocellus achieves its full service only when it passes for a detail of the background, and, on the other hand, the smallest accessory detail-picturing one has a share of intrinsic obliterative or 'dazzling' effect.*

The multifarious obliterative devices of color and pattern worn by butterflies and moths are often seconded by modifications of external form, by appendages, as in the case of birds and other animals. But the lepidopter's appendages are much more limited in kind, consisting almost exclusively of modifications of the outer edges of the wings. These are cut-in, in gentle curves or sharp, angular notches, or extended outward in longer or shorter, broader or narrower 'jags' or "tails," of many forms; in short, they are altered much and variously from the simple, average butterfly-shape. On the other hand, may it not be that even the 'normal' butterfly wings, so grotesquely large for the body, and so wonderfully marked for obliteration, are themselves

* This book aims to discuss only concealing-functions, though not forgetful of the obvious unlimitedness of the uses that Nature must make of every detail.—A. H. T.



FIG. 132. "Ocellus" or eye-spot on a butterfly model. 'Dazzling' effect, etc., see page 230, chapter XXVII. The ocellus distracts the eye's attention from the contour of the cardboard butterfly on which it is painted, and which, by likeness of shade and color, 'merges' with its background; also, the ocellus itself, when the butterfly is not detected, seems, necessarily, to be a detail of the background.



FIG. 133. Moths, butterfly and pheasant's tail resolved by picture-pattern into representations of twigs and leaves projecting over holes and shadows (Cf. Fig 120.) Polyphemus moths, *BB*, Promethea moth *C*, Antiopa butterfly *D*, Cynthia moth *A*, and Copper Pheasant's tail *E*.

obliterative 'appendages'? For the wings of most lepidoptera, and of all butterflies, are, judged in comparison with other aërial insects, and even the most aërial of birds, out of all proportion to the size of their bodies. A butterfly with a wing expanse of about seven square inches weighs about a tenth of an ounce, or less; a bee of about the same weight, with highly aërial habits, has a wing expanse of only about a third of an inch; and a much-flying bird, e. g., the Red-tailed Hawk (*Buteo borealis*), weighing about forty ounces, has only about four hundred square inches of combined wing and tail expanse. In other words, the butterfly has about twenty times the flying-spread of the bee, and at least seven times that of the hawk, in proportion to its weight. Indeed, a butterfly is so greatly 'overwinged' as to be incapable, in most cases, of steady or swift flight. Its big vans float and flutter like wind-borne leaves, carrying the little body which wields them in a tortuous, uncertain course, and making it bob up and down with every stroke—a puny and unstable fulcrum. To one who recognizes the power and importance of oblitative coloration, it seems by no means unlikely that this monstrous expanse of wing among butterflies (and some moths) is actually in itself an oblitative device—that its chief use is the delusive and effactive extension of the little edible butterfly outward into the environing vegetation and the background scenes. In every case(?), the little body itself has the very acme of oblitative coloration, based on complete counter shading. For the side view, when the wings are perpendicularly folded, it is often daintily picture-patterned; in a top view it is usually the center of dimness in a dim, smoky, blended patch of pale half-shadow tint. Literally the *center of dimness*—the dimmest and least noticeable part, from which the eye is led outward to the more or less bright markings of the widely extended wings. But these bright markings themselves are, as we have seen, potent parts of the disguise, since they picture the landscape, and lead the beholder to think he sees *through* and *beyond* where really there is an opaque surface interposed.

Here, then, is an amusing contrast between old ideas and new. On the one hand, a butterfly is hailed as the very embodiment and epitome of gay,

bright, careless life,—a dancing elf, a creature beautiful for beauty's sake alone, a reveling fellowship of four animated, glittering, flowerlike wings; while on the other hand, if we follow this new supposition, we see a butterfly as a harassed mite of vitality, for harsh need's sake encumbered with huge, masking shields, richly enwrought with illusive pictures of the scenes amidst which the mite of vitality dwells. The bee's wing and the hawk's wing are evidently formed for action, and for action only, whatever superimposed disguises they may wear; the butterfly's wing, at the present stage of its development, seems almost rather to be a *mask* which is also used for action. No doubt, however, butterflies are also protectively served in a still more direct and simple way by the disproportionate bigness of their wings—namely, by the actual elusiveness to winged insectivores which their consequent tortuosity and jerkiness of flight insures them. Watch a bird chasing a flying butterfly (which, by the way, is a decidedly uncommon happening—as if birds had learned the futility of such chases), and you will see how great is the butterfly's advantage, in spite of his offering a far broader target, over the “wheeling” beetle or even the swift, straight-flying bee. His body bobs up and down between his wings, and his wings carry him in a crazy, zigzag course—baffling, as a rule, to the most adroit ‘dodgers’ among birds.

Among the butterflies whose big, picture-patterned wings have in addition highly diversified contours, familiar examples are those of the genera *Grapta* and *Vanessa*, etc., often called “Angle wings,” and the “swallow-tailed” *Papilionidæ*.

II. Moths

There are also many long-“tailed” *moths*, like the great pale-leaf-green Luna (*Actias luna*) of North America, and the beautiful, diurnal, butterfly-like *Urania* moths of South America, etc. These *Uranias* are not only diurnal, but preëminently aërial, spending the daylight hours largely in swift and tireless flight above and through the forests. They are marked—rather

more minutely than one would expect them to be—with black, or dark shadow-brown, and iridescent green-blue, green, or golden bronze. Judging by the fineness of their rich oblitative patterns, as well as their pronounced appendages, the “tails” on their hind wings, we must suppose these moths to have habits of quiet diurnal resting or feeding, of which we know little or nothing. But the “tails” of some of them, e. g., the most beautiful *Urania leilus* (called in Trinidad the “Green Page”), undoubtedly serve them in flight, in the manner of the tails of peacocks and pheasants, etc. (Chapter XVII, p. 95)—leading enemies to strike behind them. For these tails are white (brightest at the tip, and forward blended into green), and the most conspicuous part of the moth in flight. Like the tails of certain newts and lizards (which also, as we have seen, are often thus ‘dazzlingly’ and ‘distractively’ colored), these white appendages can even be seized and torn off without grave injury to their possessor, who thereafter merely wants one safeguard. Doubtless, however, they often cause the attacker to strike entirely behind the moth. A like use, among others, is evidently subserved by all rear-end appendages of moths and butterflies—especially aerial ones, and especially when the appendages are very light colored, or transversely marked. Indeed, the same service is no doubt rendered even by the light- or bright-colored hind wings foiled by dull fore-wings, so very common among moths, although other effects of this combination are probably of more importance. It constitutes, for instance, a true ‘eclipsable dazzling costume,’ exactly corresponding to that of many butterflies. For as the butterfly, alighting, hides the dazzling-color of its upper side by folding its wings perpendicularly, so the moth alighting hides the dazzling-color of the upper side of its hind wings by folding its fore-wings flatly over them. Yet even this is probably only a subsidiary function of such markings of moths. If they catch the eye when the moth is flying, they will abet his ‘vanishment’ when he alights by their total and abrupt eclipse. Yet their main tendency is probably the *reduction* of their wearer’s conspicuousness in flight. They are, in fact, oblitative flight-patterns, like those worn by aerial butterflies. If a creature is

to fly amid surroundings much and brightly variegated, he will be the less conspicuous the more bold samples of his environment's varied spots and colors he bears on his own surface. Such an enrichment of attire for greater average inconspicuousness in flight has Nature furnished many moths, on the hind wings. When, as is common enough, these are mainly whitish, or of some very pale color, they serve a still more definite obliterative purpose, and that by night as well as, or rather better than, by day. Like the white sterns of ruminants and hares, the white back-patterns of grubbing nocturnal carnivores, etc., they often nearly or quite match the sky. Thus a white- or pale-hind-winged moth retreating in free air, especially at night, will often be quite undistinguishable against the sky, while one with dark hind wings would be plainly visible. But many *have* dark hind wings, or hind wings with strong dark markings, and such a coloration seems meant for daylight rather than for night-light use. Indeed, though most moths are almost wholly nocturnal, their costumes, with few exceptions, are doubtless specially adapted to *diurnal* use. For most of them pass the day in the open air, sitting motionless, flatly folded, on tree trunks, rocks, grass blades, dead or living leaves, or the brown, leaf-strewn forest ground. It is chiefly against discovery by daylight in such-like situations that the intensely high-wrought "cryptic" coloration of their upper sides avails them; as the often far simpler, brighter, and more boldly variegated coloration of the hind wings, wholly hidden while they are perching, avails them when, disturbed, they are forced to make a daylight flight.

But the special forte of moths' coloration lies in their finely wrought *hiding-patterns*, which, for specialization and variety, for marvelous minuteness and obliterative potency, are not to be surpassed and scarcely even to be equaled in any other branch of the entire animal kingdom. These patterns differ from the corresponding ones of butterflies (all but the few flatly-applied kinds, like the South American and West Indian "Creaker" (*Ageronia jeronia*, etc.), whose bark- and lichen-pattern is almost as exquisitely and minutely wrought as that of any moth), just as their wearers differ from the



A B
 FIG. 134. Two grass-moths. (Dead grass.) Compare Fig. 135.
 Photographed from nature (dead moths.)



FIG. 135. Tiger-moth on sprig of box. Compare with Fig. 134A.
 Photographed from life by Cherry and Richard Kearson. Courtesy Cassell and Co.

FIG. 136.



FIG. 137.



FIG. 138.



Bark-moths of the finely-grizzled type. Fig. 136, four on maple bark. Fig. 137, two on pitch pine. Fig. 138, three on gray birch.

butterflies in habits. They are far more fixed and still, in their daylight perching, and they sit *flatly applied* to their perches, instead of standing out from them perpendicularly. Thus they are fit subjects not only for higher particularization and greater minuteness of pattern, but for direct, near, flat-surface-picturing costumes, from which the element of *perspective*-picturing is largely excluded. Naturally, this rule has exceptions. There are ground-perching moths—grass moths—for instance, covered with representations like the Rocky Mountain Ptarmigan's (Figs. 40 and 41 of Chapter VII), of dry grass blades crisscrossing over a background of shadow. Such a moth is shown in Fig. 134, A. Perching among slender grasses some inches above the earth, a moth like this has often a background full of diverse distances, of little 'vistas'—and it is patterned accordingly. This, indeed, is not an uncommon type of coloration among moths, and there are many variations on it. Kindred pattern-schemes occur also among woodland moths—both terrestrial ones, which perch on fallen dead leaves, and those that are wont to sit in trees, on green or withered foliage still unfallen. (See Fig. 135.) But the vast majority of moths habitually sit pressed close against a flat or flattish surface, which wholly hides their undersides, and prevents their having any more distant background, except in extreme *side* view. The aspect of this flat surface is pictured on the shielding upper sides of the moth's fore-wings, and on its head and thorax,—or, in the case of species which sit fully outspread, on both fore and hind wings, and the entire upper surface of the body,—often with an almost microscopic particularity of detail. Only the slightest reduction from the real size of the imitated details is needed in this picture-pattern, for the space between picture and model is almost nil. Indeed, though we may pretty safely assume, in view of Nature's prodigal perfectionism, that the moth's pattern is thus as it were 'focused' for the very closest average unison with its background, the difference and its adjustment are often too slight for man's eyes to recognize with certainty. But there can be no doubt that the coloration of these flatly-applied moths is on the whole *obliterative* rather than *mimetic*; that, in other words, such a moth

characteristically seems merged into the flat plane on which it sits, rather than showing its real, slightly raised form and passing for an inanimate excrescence. Of course, however, this rule has exceptions. Any such moth must sometimes, especially in side view, present and profit by the *mimetic* instead of the *obliterative* aspect; and there may be some moth-costumes which have been developed for full and elaborate mimicry of this kind, at the expense of 'obliteration.' But that this is exceptional* is amply shown not only by the character of most moths' patterns, but by the complete oblitative shading which their usually plump bodies bear. This can be seen to best advantage on the very large-bodied kinds, notably the hawk moths (*Sphingidæ*); but—supposititious *mimetic* moths aside—there are almost no species that lack it. Usually the bodies are not only counter shaded, but marked with oblitative patterns—either such, already mentioned, as cooperate with the background-pictures on the wings, or bolder 'secant' and 'ruptive' patterns which tend to obliterate the bodies in side view, when exposed to sight below the wings. A similar service is rendered by the more or less abortive patterns of the *under* sides of the *wings*, which are usually dim and imperfect counterparts of those of the *upper* sides. In most cases, they are normally quite hidden while the moth is perching, and their frequent comparative crudeness seems therefore to be in just proportion to the smallness of their use. In flight they are of course exposed—though much less clearly than the *upper*-side patterns, because masked by shadow—and they then, especially in the cases of the brighter and bolder ones, have a distinct share of oblitative effect. On the other hand, the prevalent *pale*ness of the under sides of the wings must be classed with oblitative counter shading. But the pattern of this part of a moth is evidently of scant importance, and accordingly tends to be scantily developed, compared with the *upper*-side pattern, and with the *under*-side patterns of perpendicularly-folding butterflies.

There are, indeed, perpendicularly-folding moths, just as there are flatly applied butterflies, and the types of pattern are correspondingly interchanged.

* (If there be such cases)—A. H. T.



FIG. 139. Sphinx Moth (*Philampelus pandorus*) on a birch trunk.
Photographed from life by Dr. R. W. Shufeldt.



FIG. 140. Isolated bits of the same moth, intermingled with bits of the surrounding birch bark.

But—especially in the moths' case—these are rare exceptions to a widely comprehensive rule. On the other hand, moths' regular habit of *flat-folding* is subject to several notable modifications. Many small kinds fold up almost cylindrically, 'furling' their wings around their bodies, and when thus folded they sit fitted close to slender twigs or grass blades—like certain tree toads. Such moths often bear a mimetic likeness to bits of stick or grass, or even to bird-droppings, but often also they are patterned and colored *obliteratively*. Again, the triangularly folded wings of many tree-bark moths, etc., slope downward steeply from the top ridge of the thick body, so that the moths' picture-patterned surface is by no means actually flat.

Let us glance at a few more special types of pattern characteristic of 'close-lying' moths in general. Among all the various perches which these moths frequent, few or none are so abundantly favored by them as tree trunks. Accordingly, the tree-bark pattern, in various forms, is probably the most prevalent of all picture-patterns on moths' wings. The two extremes of this form of marking are: first, a pattern of the finest grizzling and speckling, which counterfeits with exquisite minuteness the look of finely broken bark, flecked with tiny lichens, etc. (see Figs. 136-138), and second, a pattern which depicts the larger details of rough or ragged bark, rendering, by contrasts of dark and light, by sharp lines and soft blendings, the look of sharp-edged substances casting shadows on their background. Each of these types, as is almost needless to say, is subject to multitudinous variations, and the two extremes are combined and intergraded to the last degree. A beautiful example of the larger-detail type, pure and simple, is the sphinx moth shown in Fig. 139. (See also Fig. 140.) But there are some still further specialized cases of bark-picturing among moths, sometimes accompanied by highly specialized habits. A large gray noctuid moth which I saw in the woods of Trinidad, B. W. I., always perched *sideways* on the trunks of trees and bushes. That is, it would sit with flatly-applied wings trending up and down the trunk instead of across it. Its flight was swift and straightforward, but in alighting it always whipped itself around into the sidewise posture. The reason, or at

least a most significant accompaniment, of this peculiar habit, was not far to seek. The 'secant' stripe, crossing the insect transversely from fore-wing tip to fore-wing tip (a type of marking very common among moths, whose patterns, like those of butterflies, are built on the simple basic laws of 'obliteration'), was on this kind specialized into a wonderfully sharp and vivid picture of a vertical bark-ridge. Such picturing of *outstanding substance and cast shadow* plays a large part in the disguise of many animals of many classes,—nor is it, among moths, confined to those that perch on tree trunks. It reaches equally high and various development among the ground-perching kinds. These—the sylvan ones at least—tend to be *brown* (as the perchers on tree trunks tend to be *gray*). Their general scheme of color and pattern is much like that of the sylvan terrestrial butterflies, but they sit, for the most part, flatly applied, instead of perpendicularly folded, and therefore need still more direct and simple ground-picturing patterns. Sometimes, indeed, they present a resemblance hardly other than *mimetic* to single, brown, dead leaves. No doubt there are even full-blown brown-leaf mimics among them, as there are probably green-leaf mimics among those that perch on live foliage. But in the main, their coloration is *obliterative*, not mimetic—if anything, more patently so than the corresponding coloration of the bark-perchers. The leaf-strewn forest floor is more uneven, more studded with projections and pitted with depressions, than are tree trunks, and though a moth sits flatly outspread on it, his background tends to be less evenly and plainly *near* than is the bark moth's. And, though the ground moths' "cryptic" patterns contain less of the element of diverse-distance picturing than do those of the perpendicularly-folding butterflies which haunt like situations, the essential differences between the disguises of these two lepidopterous types are comparatively small, and sometimes quite in abeyance. Again, there is even close likeness between the patterns of some of these moths and that of certain terrestrial snakes, such as the Copperhead (Plate XI). Both picture dead, prostrate leaves, with their light, sharp edges and blurred shadows. For pure and subtile realism, the background-pictures worn by some

of these larger leaf-moths are hardly to be matched in any other branch of the animal kingdom. (See Fig. 133, B, B and C.)

In the disguise of butterflies and moths alike there is one seeming flaw, perhaps supported by insuperable organic limitations. That is, their usually perfect dual symmetry in all details of pattern.* The markings of the two wings on one side are as a rule almost exactly duplicated by those of the opposite pair; and such duality and repetition tends to attract the notice of the seeking eye. Of course it is only when the wings are outspread that this duality becomes in any degree a defect. Upfolded, a butterfly, though still dually symmetrical in fact, is not so in effect, any more than a bird or mammal is, for only one side can be seen at a time. Indeed, even when a moth or butterfly is *outspread*, its duality is usually frustrated in effect simply by the irregularity of its position relative to the eye. Birds, on the other hand, which tip and twist their heads, peeping and prying, with eyes in all sorts of irregular positions, must often see moths and butterflies symmetrical where we should not. Among moths this duality is often masked by sharp stripes which cross continuously the whole extent of the expanded or triangularly part-folded wings. Such a stripe, with its two sides unlike, 'cuts' the moth into two very unequal parts, dividing it across the direction of its dual symmetry, while the 'secant' itself pictures some landscape-detail—a stick or bark-ridge or leaf-stem, with a shadow on one side of it. Sometimes a marking of this kind cuts the fore-wings (or, more rarely, the hind wings) longitudinally, either crossing or skipping the intervening body; but as a rule it is diagonal, forming one clearly continuous (though not always straight) 'secant' stripe when the wings are folded in the normal resting-posture. There are many wearers and manifold variations of this marking, which, though often so very simple, is one of the most potent of the fundamentally 'obliterative' details of lepidopterous pattern.

It takes the eye of an artist, as we have said before, to recognize the wonder-

* Of course, both sides of the insect need, in the long run, just the same pattern; while a score of circumstances tend to rescue it from betraying its actual duality.—A. H. T.

ful truthfulness of all these pictures which Nature paints. They are all—whether of bird, beast, fish, snake, or butterfly—not mere *approximations*, but *essentially and typically true*. (The reader must excuse the repetition of formulas and phrases calculated to bring home to him a vital but most subtle and illusive truth.) There is sense in the seeming paradox that a good caricature portrait of a man looks more like the man than he does himself; and there is far more sense in the equally paradoxical sounding statement that the background-pictures worn by animals exceed their subjects in verisimilitude. For these pictures are not only somewhat caricatured, they are at the same time *epitomized, compounded*. *Caricature of the average*—a seeming contradiction in terms—is a phrase that fits the case. The salient and essential attributes of the pictured scenes have been slightly exaggerated, and cleared of all that is uncharacteristic. Many scenes have been merged into one, but all have yielded only what is typical and essential. A leaf is a leaf, and has nothing to lose by looking ordinarily leaf-like and no more, but a moth is not a leaf, and, if it is to profit by passing for one, it has much to gain by looking extraordinarily leaf-like—for so will the marauder's eye, seeking it as a moth, be the more surely balked from detecting it. Intensified qualities of pure leaf-like-ness of aspect no marauder will easily learn to associate with something which is wholly foreign to leaves in its real nature.

All this being so, is it any wonder that artists should feel keen delight in looking at the disguising-patterns worn by animals? They are, in the best sense of the word, triumphs of *art*; and in a sense they are *absolute*, as human art can never be. He who would learn the *surely typical* color- and pattern-scheme of a particular kind or detail of natural landscape—tree-bark, leaf-strewn ground, or what-not—has only to look at the disguising-costume of the moth or snake or bird or butterfly which habitually has such a background. There he will find it in epitome, painted and perfected by Nature herself. Color and pattern, line and shading,—all are *true* beyond the power of man to imitate, or even fully to discern.

APPENDIX A

(Professor E. B. Poulton has kindly given us permission to append the following very remarkable addition to our subject.)

[*Extracts from*] A few Notes on South African Chamæleons, &c. By G. B. LONGSTAFF, D.M., M.A., of New College, Oxford, and EDWARD B. POULTON, D.Sc., M.A., F.R.S., Hope Professor of Zoology in the University of Oxford, and Fellow of Jesus College, Oxford.*

THE following observations were made during the visit of the British Association to South Africa in 1905. The conditions were not favourable to continuous investigation: nevertheless, I believe that some of these scattered notes are not without interest, especially those referring to the automatic adjustable countergrading of shadow on the two sides of the chamæleon. It is probable that the independent control of the colours of the two sides of the body has been often observed before, but, so far as I am aware, this is the first attempt to explain the significance of the power. The illuminating effect of a great hypothesis like that of Mr. Abbott H. Thayer's in the realm of protective coloration is well seen in the fact that Dr. Longstaff, Professor C. V. Boys, and the present writer independently grasped the meaning of the colour-change the moment it took place before their eyes. I do not know whether my two friends have studied Mr. Thayer's writings or examined his beautiful models at London, Oxford, or Cambridge,† but I have no doubt that it is the result of his work that interpretation was "in the air."

I have to thank Mr. G. A. Boulenger, F.R.S., for kindly naming the specimens upon which the following observations were made.—E. B. P.

* (Read 7th March, 1907.) [Printed in the Linnean Society's Journal—Zoology, Vol. XXX, October, 1907.]

† [I was familiar with Mr. Thayer's models.—G. B. L., July 17, 1907.]

3. *Note on CHAMELEON PUMILUS, Daudin, ♀. By Dr. G. B. LONGSTAFF.*

Taken on a shrub, about four feet from ground, in the Botanical Gardens, Cape Town, 9th August, 1905.

Description.—Apple-green; at the back of the eye two patches of greyish-pink placed vertically; a lateral stripe of the same colour extending from shoulder to pelvis, widest in middle, where are two dark grey spots. Several orange tubercles on the back. Belly striped with greenish white; underside of head striped blue-green and pink. The ground varies to dusky green.

Kept in confinement. Observations on same made at Durban, 16th Aug., 1905. After it had been kept for some time in the dark it became of the brightest apple-green. On exposure to light it darkened. Placed on a dark "uniform-case" near the window in bright light it darkened *along the dorsal area*.

Taken out into the garden and placed alternately on a black pair of trowsers and on a white towel. It darkened in both cases, but there was no noticeable difference. Then put on a twig of a shrub with bright green leaves it became paler. The side *away from the sun* was of the brightest apple-green, the outer side (towards the sun) was *darker along the back*. The bright green harmonized wonderfully with the young leaves, the creature appeared flat, and was scarcely distinguishable. The neck and belly did not appear to change colour. * * *

4. *By Professor E. B. POULTON.*

* * * Good fortune gave me as companions in the same compartment of the train two physicist friends, Captain Creak, F.R.S., and Professor C. V. Boys, F.R.S. One day, when *C. pumilus* was resting on the compartment table, with the long axis of its body parallel to the window, Professor Boys, who was certainly intended for a naturalist, pointed out that the strongly illuminated side, next to the window, was dark green, while the side in deep shadow,

away from the light, was of the brightest tint. The same relationship between the illuminated and the unilluminated side was seen on many occasions.

This appears to be a most interesting adaptation—a dynamic manifestation—of the principle discovered in its static form by Mr. Abbott H. Thayer. Mr. Thayer first suggested that the relative shades of the dark back, lighter sides, and white under sides of animals were such as just to counterbalance the diminution of natural illumination from an open sky as we pass from the back down the sides to the under surface; that the object of this countergrading was to neutralise the shadow which would otherwise render the animal conspicuous. *C. pumilus*, as I have said, manifests the same principle in a dynamic form. The side that happens to be turned away from the light is brightened sufficiently to neutralise the shadow; the high illumination of the other side is toned down by darkening, the effect being that all appearance of solidity is dissipated. This result must be of great importance to so large and so defenceless an animal as the chamæleon. But for this adjustable countergrading, the varying degrees of illumination on the side and dorsal slope turned towards the light, combined with the strong shadow on the other side, would cause it to stand out among the leaves as an object of conspicuous solidity and thickness.

APPENDIX B

ADDITIONAL NOTES BY A. H. THAYER

CONSISTING OF OBSERVATIONS MADE TOO LATE TO BE EMBODIED IN
THE TEXT OF THE BOOK

DURING the progress of this book I have been discovering another beautiful fact about iridescence—one that was, of course, to be expected. The beautiful colors which compose it, and which leap into existence with the changing position of the wearer, or of the beholder, are evidently not mere *general* attempts at obliteration of the wearer, but are, each, so many *perfect color-notes of that background which the changed situation demands*.

We have already shown that the peacock's neck is often leaf-green when looked *down* at, and pure blue sky-color when looked *up* at, so that it tends to fit itself exactly to each new background. It is now evident that other animals' iridescences are, like those of the peacock, repertories of exact background colors. The gloss of the magpie's wing is at one moment a glimpse of sunlit evergreen, while the next instant it is the blue snow-shadow beyond the tree. In this way this very snow-picture, so perfectly achieved on the jays by dead color, is reached with equal precision on the magpie by one leap of iridescence. Throughout the world of brilliant animals, we find iridescence playing this same part. The cormorant's green gloss in the water, looked *up* at from deeper down, proves to be a perfect match for the translucent water itself. The crow's rainbow sheens, so little thought of as concealers, turn him into such true distance-colors as he sits on the nest, as to rank him at this moment almost with the grouse for indistinguishability. (The nest itself, of course, has the disadvantage of attracting the eye, and thereby subjecting the occupant to a far keener scrutiny than the grouse

has to fear. Since crows are apparently too unappetizing, as well as perhaps too formidable, to be much bothered by predatory animals, it would seem to be the eggs, and not the parents, that here most need protection.)

What we know of the concealing-function of such costumes as that of the black-and-red South American *Heliconii* will bear further elucidating. These insects, in their abundance, and consequent general conspicuousness as a species, are on a par with our common yellow butterfly* here in the North. Both these species, existing in such immense numbers as to be almost constantly in sight, record, on the beholder's mind, one cumulative impression of conspicuousness. Yet each is colored for the utmost average concealment, at the very time when it most needs it—its feeding time. Such species are merely further proof of what our book demonstrates, viz., that Nature, in carrying out her principle of coloring animals for their most trying circumstances, sometimes finds herself giving to a species that has one particularly dangerous habit, a coloration which, while it is the utmost imaginable concealer in the special situation it fits, looks necessarily more or less conspicuous and out of place everywhere else.

These brilliant *Heliconii*, so magically concealed by their colors while they are feeding among red, yellow, or orange flowers, seem to be greatly indebted, during the rest of their day, to the protecting power of their habit of threading, with their rather slow flight, the interstices of dense foliage, where fly-catching birds have but a poor chance to capture them. In this habit of haunting the dense foliage, as well as in their colors, these *Heliconii* remind one of Scarlet Tanagers—a fact worthy of notice.

There is no need of going to the tropics to study the concealing-power of the coloration of one of these red-and-black or yellow-and-black *Heliconii*. Place a dead one, or even an artificial one, on any kind of plant that has either red, yellow, or orange flowers, and not only will you find it wonderfully concealed, but you will perceive that the principle on which this concealment is achieved would always be operant wherever such a butterfly sat among such flowers.

**Colyas*.

One word more about Scarlet Tanagers. Their coloration, dividing them as it does into two things, a red thing and a black thing, is clear proof that conspicuousness is not what is aimed at. Were these birds meant to be conspicuous, they would, all the more because of inhabiting dense foliage, be monochrome. (The principle which underlies this fact is illustrated by the diagrams of letters in Plate V.)

The rule seems to hold good that since animals must first of all breed, feed, and drink, their costumes will prove to be pictures of the scenes of these operations. To speak here only of the feeding (the thing that occupies far the largest part, for instance of a male bird's time), there is among birds every degree of peculiarity of feeding-situation, from that of the hawk, which is the least peculiar—being wherever, in all outdoors, he gets a sufficiently good chance at a victim—to that of the macaw, which is one of the most peculiar and unvarying, commonly some tree-top full of luscious fruit, where he has merely to climb about a few feet to sate himself. What more powerful influence toward dangerous relaxation of vigilance could be imagined? What wonder, then, since the macaw's banquet-hall is forever hung with one gorgeous tapestry of fruit and foliage scenes with sky-glimpses between, that his costume proves to be such as marvellously dissolves him into the scene, as he climbs about, burying his head in cluster after cluster of the brilliant fruit? This was just as much to be expected as that the hawk, whose feats take place now in one situation, now in another, should wear the very most generalized of concealment costumes.

UPPER-SIDE WHITE PATCHES, ETC.

It is perhaps possible to show still more clearly than we have yet pointed out the paramount function of *upper-side* white patches in general.

In imitating, as we have shown that they do, sky-glimpses through interstices of the foliage-background, they pass off those parts of their wearer which they cover, for *spaces*,—more emphatically than spots of any other color could. The reason of this is that sky, the element which they represent, *is the very*

essence of distance. All other colors seen amidst the foliage might represent one or another of its details, and any one of them occurring on an inhabitant helps to conceal him; but the finishing touch is given by his wearing, generally on his very middle, this picture of sky, which, because sky of course is not *in* the wood at all, but immeasurably far beyond it, here represents no *thing* whatever, but an actual *hole*. When we say, "I can see daylight right through the place," we imply that there is nothing in that direction between our eyes and space. A white patch, then, in any such situation, whenever the light falls upon it sufficiently strongly, says clearly to the beholder, "There is nothing in this direction." No wonder that such a vast number of species that have sky glimpses in their foliage-background wear in their costumes this magical safeguard. Even in dark woods where white itself is much darkened, and where actual sky-glimpses are few, it is still the prerogative of these white patterns to represent, and more or less to *match*, the lightest, most illuminated and sky-like portions of the background. In general, the credit of white as an unmistakable glimpse of sky through the trees is so good that imitations of it easily profit by its name. There are often in sight a thousand real sky-vistas—how shall a hawk or other animal spend its energy in guarding against the occasional counterfeit! The fact undoubtedly is, that disguise, by all the means that we have pointed out, proves so successful as to discourage investigation, causing it to better repay predatory animals to watch merely for *motion*, and waste little effort in scrutiny of motionless details.

Since the whole panorama of out-door objects is just one complexity of millions of outlines made by different-colored objects relieving one against another, each one showing against a *more distant one*, it follows that amidst this vast embroidery, a scrap of imitation of it must generally pass unnoticed, *unless it takes the liberty of moving about!* All the patterns and ornaments of the animal world are such scraps of imitation scenery, and their wearers are hunted both by man and by beast in the same way—viz., the watching with a relaxed eye as large a tract as possible for the least hint of *motion*.

Habitually to scrutinize the scene point by point would change an Accipiter's or a Flycatcher's life from a sufficiently easy to a most difficult one, such as would bring him near the starvation point, since he would necessarily bestow a large amount of his time in searching the wrong place, while his eyes no longer commanded the whole scene. The very position of Hawks' and Flycatcher's eyes seems to prove all this to be true, since they face one eye to the left and one to the right, and therefore commonly regard two different scenes. No one can suppose that such a bird performs a feat of intellect beyond even a man's power, and acutely *examines* with focused eyes two points at once. An Owl's eyes, on the contrary, not constituting his stand-by sense, but needed at the grabbing-moment, face forward. Also, most interesting to record, the Hawk's eyes, not to be wanting in *any* service, *turn* forward, and assume the position of those of the Owl whenever the occasion demands.

The fact that every pattern in the forest scene is caused by a thing of one color outlining against things of a different color *beyond*, makes it inevitable that *similarly*-colored notes on the coats of *animals* amidst the scene should receive a similar interpretation, and repeatedly pass off one or the other part of the wearer for something more distant than the rest of him, thus concealing his existence. Hunters and collectors will find that these explanations show why they see so few of the inhabitants of the field or forest until they have once flushed them. Up to that moment each bright detail of these animals' costumes has commonly passed for a glimpse of something nearer or further than the thing represented by the rest of their colors.

The longer one studies the subject of concealing-colors, the greater the part one discovers to be played by the intrinsic oblitative power of strongly contrasting patterns. This principle is shown by Figs. 104-106 in our book, but should have received much more varied and elaborate illustration. We are forced, now, to leave the reader to make his own further illustrations. Let him cut out of very dark paper or cloth (cloth is best because it shows no light edge) some shape,—like, for instance, that of a butterfly,—and pin it, smooth and flat, upon a smooth expanse of cloth of some very slightly darker color.

Then, while he looks at this figure from nearly as far off as he can distinguish it from its background, let some one place a bit of bright white paper, likewise smooth and flat, in the middle of the end part of one of the butterfly's wings. (The white spot should be about one third the wing's diameter.) The wing so treated, if it was very dimly distinguishable before, will now prove wholly invisible, in the vicinity of the white spot. This beautiful principle is of course a constant factor in the effect of all animals' patterns,—snakes, wasps, butterflies, birds, etc.—and, in the sense that *counter shading* merely prepares animals' bodies, as it were, to be painted upon, this other principle is almost the leading one of all. Such a butterfly as *Heliconius amaryllis* is a fine example. Against the dark of shadows that nearly match its own dark ground-color, its red spots 'obliterate' its adjacent outlines, and the sharp gold stripe that crosses the hind wings does the same for that part of the insect. The bright bar also illustrates the importance of the *direction* of such marks on animals. Being continuous (with very slight interruption) right across the insect's very body, it not only 'obliterates' it as a body, but, by its own conspicuousness,—in view of the fact that two things can't occupy the same space,—prevents one's suspecting the existence at that point of anything but a yellow grass-stem, or more often a sunlit twig, further off.

Students once convinced of the real function of all such markings, will be delighted to discover the wonder-world they constitute.

THE COÖPERATION OF INTERPOSED VEGETATION WITH CONCEALING-COLORS

Here is another fact of the greatest importance: *Species that live amidst vegetation are looked at through a certain average amount of interposed foliage and twiggerly.*

Let us imagine a man or other predatory animal stationed at some point in the forest. Obviously there is some limit to the distance to which he can see through the surrounding thicket, some point beyond which the last interstice is masked by leaves or branches. A little nearer than this limit begins the distance at which our observer can see, on an average, some small portion

of an object. Now from this point to the very space in which the observer stands there is a graded scale of the average amount of an object's surface which would at each particular distance be visible to him. We have learned from the diagrams in Plate V. that behind such a foliage lace-work *any* diversification of forest colors constitutes a costume more favorable to disguise than any monochrome. We have every reason to believe that these vegetation-haunters wear designs absolutely adjusted to coöperation with this ever-present screen.

While a naturalist is observing one Skunk, and conceiving its ruptive pattern a badge to advertise it, there are at the same moment (or there have been in the twilight and starlight of the previous night), thousands of other Skunks absolutely unrecognizable through the disruptive effect of their bleached-leaf-and shadow-colors seen through the interrupting tracery of forest under-growth, or of the rank vegetation of the prairie.

ACKNOWLEDGMENTS, ETC.

There are several men not mentioned in our book (written, mainly, several years ago) whom we should like to thank for generous furtherance, of one sort or another. Particularly, Alfred Russell Wallace, Sir E. Ray Lankester, and Mr. R. I. Pocock, in England, and Dr. C. Hart Merriam and Dr. J. A. Allen, in America. Mr. Pocock, furthermore, as shown by his various essays on protective coloration, has, independently, an unusually wide grasp on the whole subject. Had we seen his articles in time, they would of necessity have modified in some degree the *exclusive* tone of my Introduction, as well as my son's allusions here and there to the comparative apathy and blindness of naturalists in this matter.

I take this opportunity also to correct, up to the limits of my present knowledge, several errors which appear in my earlier writings. One of these is my indorsement of Dr. C. Hart Merriam's theory about white rear-patches on deer, hares, etc. (Auk, Vol. XVII, No. 2, April, 1901.) Another is my avowed belief that there must somewhere be warning colors. (Transactions

of the Entomological Society of London, December 24, 1903.) This belief I no longer hold. Another is my statement, in the same article, that unshiny, bright monochrome constitutes intrinsically conspicuous coloration. Here I should have omitted the word *bright*.

In the same paper, too, I wrote, by a slip of the mind, that animals have totally different sight from ours. On the contrary, everything that we know about this matter points to the opposite belief. What I was trying to say was simply that animals seem to have a different mental attitude toward their sight, since they appear to detect each other more exclusively than we do through perceiving each other's motion.

Lastly, in the same paper, I ascribed more importance to butterflies' resemblance to flowers, as compared to their rendering of scenery, than I now should.

A. H. THAYER.

San Remo, Italy.

December 28, 1908.

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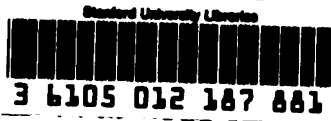


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